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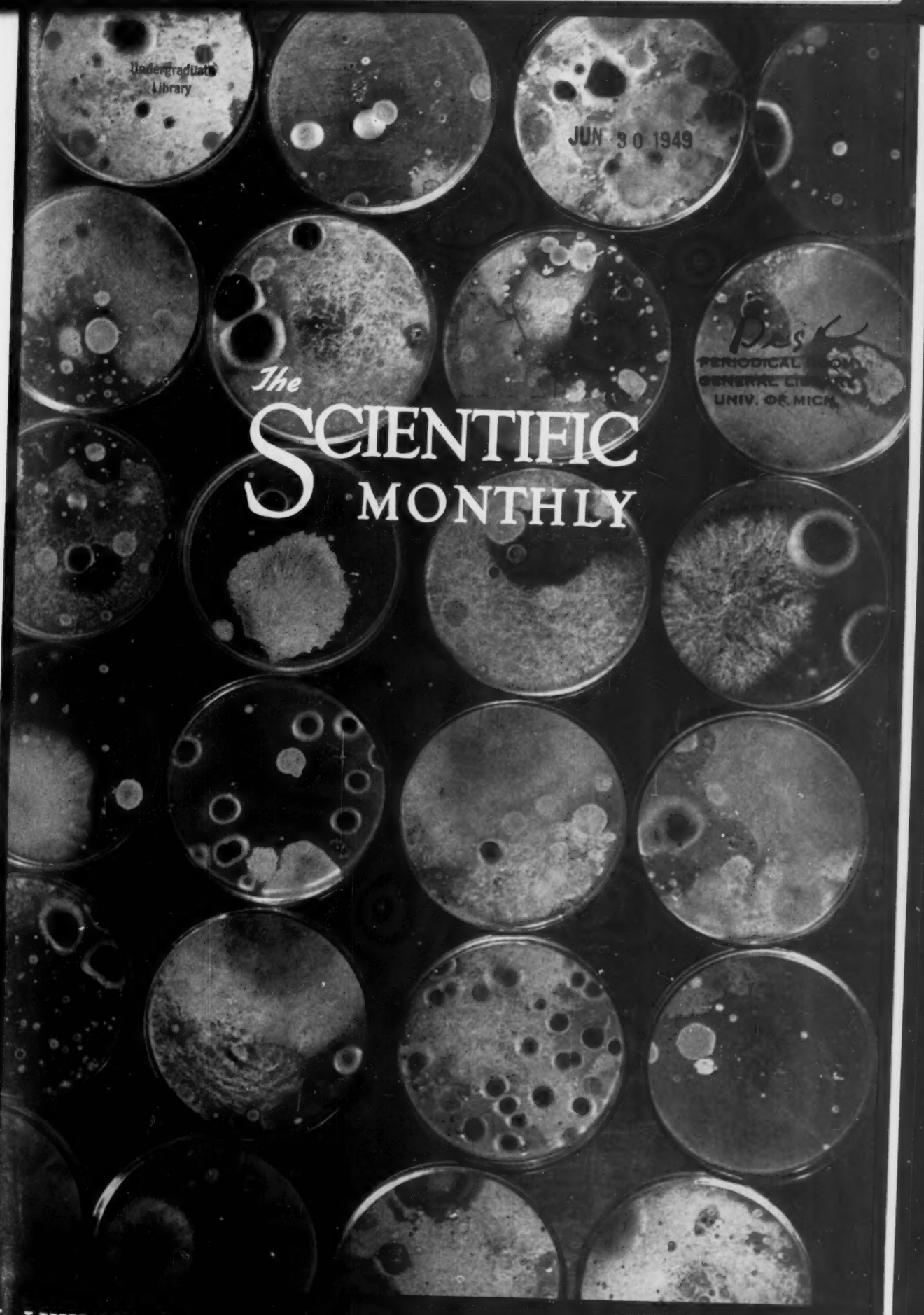
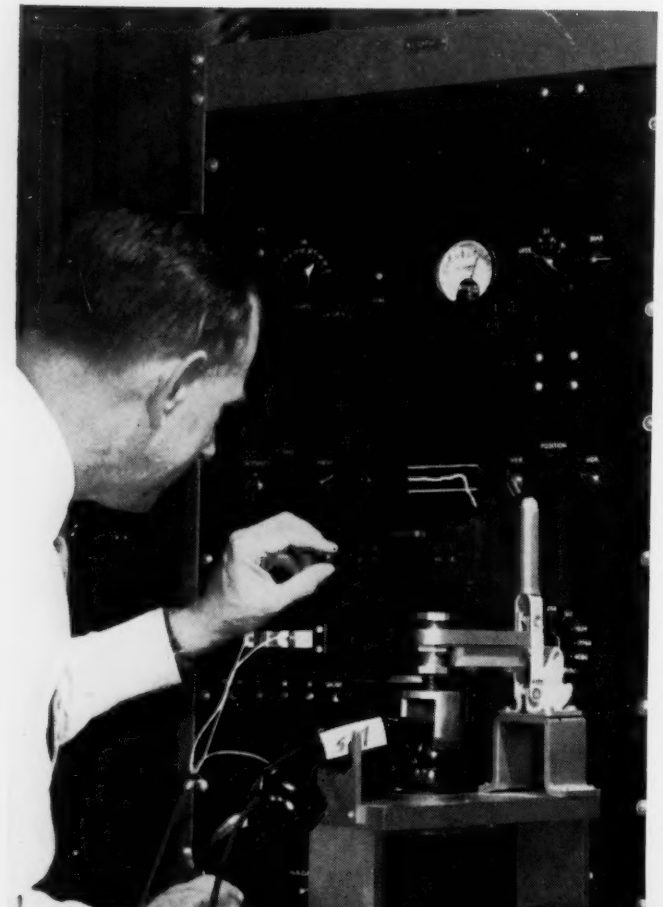


The SCIENTIFIC MONTHLY

LXIX NO. 1



YOUR telephone receiver should treat each tone in the voice alike; that is important to you, because proper balance makes pleasant listening and easy understanding. Naturalness in receiver performance is pictured in a matter of seconds by the apparatus shown at left.

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THE
SCIENTIFIC MONTHLY

JULY 1949

AUREOMYCIN

PERRIN H. LONG

Dr. Long (M.D., Michigan, 1924) has been on the medical staff of The Johns Hopkins University since 1929, except for service as Colonel in the Army Medical Corps during World War II. He has been professor of preventive medicine and head of the Department since 1940. In the fields of bacteriology, filterable viruses, and chemotherapy he has served as an associate of the Rockefeller Institute, as consultant to the Secretary of War, and on many committees.

SOME twelve years ago a prominent member of the staff of Queen Charlotte's Hospital in London, who had reviewed the cases of childbirth fever in that hospital that had been treated with Prontosil (the first sulfa drug) by Leonard Colebrook, made the following statement: "It is a matter of personal fancy which of these alternative explanations appeals to any of us as individuals, but the accumulated experience of the past shows that a fortuitous change in the virulence of a prevalent organism is no more improbable than the discovery of an effective chemotherapeutic substance." As a rule, the saying that "the old order dies hard" is as true in medicine as in any other line of endeavor, but, at the time the above words were being published, this for once was not true, and the early sulfa drugs were receiving wide acceptance by physicians and were being demanded by their patients.

The success of the sulfonamides was instant and spectacular, and, as new derivative after new derivative was synthesized, each with wider therapeutic properties, and with greater or lesser toxic potentialities, it was not strange that scientists began to search for other substances, which might be more effective and less toxic, for use as therapeutic agents in combating infectious diseases. There can be little doubt that the success of the sulfa drugs played an important role in stimulating a much more rapid development of the antibiotics than would otherwise have occurred.

The idea of using bacterial or mold-growth products for treating infectious diseases is not a new one. For more than fifty years physicians have dabbled off and on with substances derived from microorganisms. In 1929, Fleming, after describing the antibacterial effects of penicillin, definitely spoke of the possibilities of its use in wet dressings for combating certain types of infection, and later the work of Rene Dubos with Gramacidin showed that microbial products could exert powerful antiinfective effects. So it was not exactly surprising to those who were interested in the field of antibiotics to find the Floreys describing in 1940–41 the beneficial effects of penicillin in experimental and clinical infections. One must hasten to add that this is in no way a disparagement of their work, which ushered in one of the great eras in the treatment of infectious disease. It is only to show that the utilization of the antibiotic effects of penicillin was not a completely unexpected event.

The advent of penicillin, with its extraordinary ability to cure certain diseases, its relatively low toxicity, and its appearance during wartime when its therapeutic potentialities made it a military supply of extreme importance, stimulated work in

the field of antibiotics well beyond that which probably would have been witnessed in peaceful times. Biologists both at home and abroad began exploring bacteria, molds, fungi, and higher plants for products that might serve as antibacterial agents. Soil samples from their own front yards and from remote parts of the world, and stock cultures of bacteria, molds, etc., were tested by microbiologists in attempts to discover new, more potent, and more widely effective antibiotics. It is interesting to note, however, that until recently only one really effective agent—streptomycin—was developed, although the amount of work involved in this search was prodigious.

This is not surprising. Penicillin, although highly effective against spirochetal and coccal diseases, was not very effective against diseases produced by certain gram-negative bacilli. Then, too, although it could be taken by mouth, the favored and most effective way of administering it to the patient was by injection, a method most people find disagreeable. Streptomycin was very effective against gram-negative bacillary infections and was the first of the antibiotics to show any real value in the treatment of tuberculosis. It, too, had to be given by injection, it had the further disadvantage of producing certain disagreeable toxic effects, and microorganisms often become quickly resistant to its effects. Thus it can be seen that there was a real reason for looking for an antibiotic that would have a wide range of action, little serious organic toxicity, and that could be given by mouth.

In 1947, in the laboratories of Dr. B. M. Duggar, the consulting mycologist to the Lederle Laboratories Division of the American Cyanamid Company, tests were being carried out on specimens of bacteria and molds that had been isolated from soils obtained in many parts of the world. Among them was actinomyces No. 377, which had been isolated from a sample of soil sent to his laboratory from Illinois. The cultivation of this soil upon appropriate media revealed the presence of a golden-yellow mold, which was quickly identified as a member of the Streptomyces family, and was found to produce an antibiotic which, in the test tube or on agar plates, inhibited or retarded the growth of more than fifty species of microorganisms. Then a study was begun to determine what variety of a Streptomyces this new strain was, because it was known that several species of Streptomyces were capable of producing a yellow pigment. Exhaustive studies soon showed that this mold represented a hitherto undescribed species of Streptomyces, to which was given the name Streptomyces aureofasciens.

It is not to be supposed that the other research laboratories in Lederle's were marking time while Dr. Duggar was identifying and classifying the new mold. Far from it, in fact. Under the able leadership of Dr. Y. Subbarow, the chemistry, toxicology, pharmacology, and experimental therapeutic effectiveness of the new antibiotic, to which the laboratory number of A-377 was given, were being investigated. From the toxicological laboratory came the report, "Relatively non-toxic in acute and chronic toxicity tests in mice, rats, and other animals." From the pharmacological laboratory: "A-377 is absorbed into the blood and excreted in the urine when it is given by mouth to animals." From the chemical laboratory: "A-377 has been analyzed and its components determined. While its chemical structure has not yet been defined, it is possible to crystallize the hydrochloride salt of the antibiotic in a fairly pure state." From the rickettsial laboratory of Dr. Harold Cox: "A-377 inhibits the growth of rickettsia in chick embryos." From the experimental therapeutic laboratory: "A-377 cures experimental pneumococcal, streptococcal, Friedlander's bacillary, and other infections in mice and chickens." And from the viral laboratory: "A-377 inhibits the growth of lymphogranuloma venereum and of psittacosis in experimental infections in chick embryos."

While these tests were being conducted in the laboratories at Pearl River, comparable experiments with aureomycin were being done in the Thorndike Memorial Laboratory at the Boston City Hospital and at Johns Hopkins. Interested groups in those medical centers confirmed and extended the observations made at Lederle's. It was not, however, all smooth sailing. At first, in one of the laboratories it appeared that, when comparisons were carried out to determine the relative effectiveness of aureomycin and penicillin in experimental streptococcal or pneumococcal infections in mice, the latter was always much more effective. After considerable experimental work, however, it was found that this was only apparently true, and, later, when clinical tests were at hand, it was noted that aureomycin almost invariably proved to be more effective in treating infections in human beings than one would have been led to suspect from the results obtained in treating experimental mice, rats, or rabbits. This was a very interesting point because, with the sulfa drugs and other antibiotics, the reverse was frequently true.

Clinical tests with aureomycin began in January 1948, when suitable samples of the antibiotic were sent to the Presbyterian, New York, and Harlem Hospitals in New York City; the Boston City Hospital; Johns Hopkins; the George Washington

Medical School in Washington; and the University of California Hospital. The first patients treated were suffering from a venereal viral disease known as lymphogranuloma venereum. The virus causing this disease is classed as a "large" virus and belongs to the group which includes the viruses of parrot fever, pigeon fever, etc., and in which it is believed the yet uncharacterized virus of primary atypical pneumonia belongs. Prior to the advent of aureomycin, moderately satisfactory therapeutic results had been obtained by using sulfadiazine or penicillin in lymphogranuloma. It became quickly evident that aureomycin was superior therapeutically to either of these agents, and also more rapid in its curative effect. Acute and subacute instances of this disease were arrested within a few weeks after treatment with this new antibiotic was begun.

As clear-cut evidence had been obtained in the Laboratory that aureomycin was capable of producing an antibiotic effect against Rickettsia, it was obvious that a clinical test was indicated in Rocky Mountain Spotted Fever, Eastern variety. This disease is carried by the wood tick *Dermacentor variabilis* and is found over the eastern half of the United States. It is especially prevalent in Maryland, the District of Columbia, and Virginia. It occurs commonly from June to September, and the infection results from rubbing the excreta of infected ticks into the microscopic wound in the skin which the tick makes while taking its blood meal from human beings. In the past, about 20 percent of the individuals who contracted this disease died. In 1946, this case fatality rate was decreased following the use of para-amino-benzoic-acid in the treatment of this disease. This latter agent, although quite effective as a therapeutic agent, did, however, cause a number of serious toxic reactions. As was to be expected, aureomycin proved to be effective in this disease. The duration of fever was markedly shortened, the rash disappeared quickly, the distressing symptoms of head- and backache were short-lived, the complications of the disease were reduced almost to nil, and in the reported series there were no deaths.

Another rickettsial disease that is apparently increasing in importance in this country is Q(uery) fever, which was first described about fifteen years ago in Australia. It takes the form of a debilitating pneumonia and, although the death rate from this disease is not great, it can be a difficult disease for the patient and physician alike. It can occur in epidemic waves, and, although the infecting organism has been found in milk, its method of spread (especially in epidemics) is not well understood. The therapeutic effects of aureomycin in this disease have been excellent, as demonstrated by workers in the hospital of the University of California and the California State Viral Laboratory, and one can now say that there is a cure for it. In other rickettsial diseases such as endemic (rat) typhus, epidemic typhus, scrub typhus, and Brill's disease, equally satisfactory results have been obtained when patients ill with these diseases have been treated with aureomycin. As a matter of fact, physicians can now feel quite confident that they and the patient need have little fear as to the outcome of a rickettsial infection if treatment with aureomycin is started before the patient is at death's door. This marks another milestone in the conquest of disease.

Undulant fever (Malta fever, brucellosis) can be one of the most miserable of the diseases that affect mankind. It is often insidious in its onset, it may be very difficult to diagnose definitely, it can be characterized by recurrent bouts of fever and malaise occurring sometimes for years, inbetween the periods of fever its sufferers often experience lassitude and numerous minor but aggravating symptoms, and although few people are recorded annually in the mortality statistics as dying from undulant fever, this disease has ruined the productive life of many individuals. In this country it is contracted primarily from drinking unpasteurized milk from cows that have the disease, although it may result from eating undercooked pork or beef, or from contact with infected cows, pigs, or horses. It is a disease of rural people, stockyard workers, and veterinarians. It is not known how many people have brucellosis and recover completely after the initial attack. Although sulfa drugs and combinations of these drugs with streptomycin had some curative or arresting effect in this disease, their uses as therapeutic agents left much to be desired. It would appear from the reports now available that aureomycin has a real curative effect in patients acutely ill with this disease. The temperature comes down to normal within two or three days in patients who are adequately treated, and, after the course of therapy is completed, there is every reason to believe that in the majority of patients the cure effected is permanent.

In chronic undulant fever the results of treatment with aureomycin have not been as clean-cut. To begin with, unless one has a very definite history of a proved acute attack of the disease, and then typical symptoms and signs of a recrudescence together with diagnostic laboratory tests of value, the diagnosis of chronic undulant fever is fraught with difficulties and error. It seems quite likely that a number of people in this country today, who believe they have the chronic form of the disease, have nothing of the sort, and represent individuals

in whom the diagnosis is in error. It is for this reason that the results that have been obtained so far from the use of aureomycin in chronic undulant fever have been spotty. Obviously, the antibiotic will be ineffective if the patient treated does not have undulant fever.

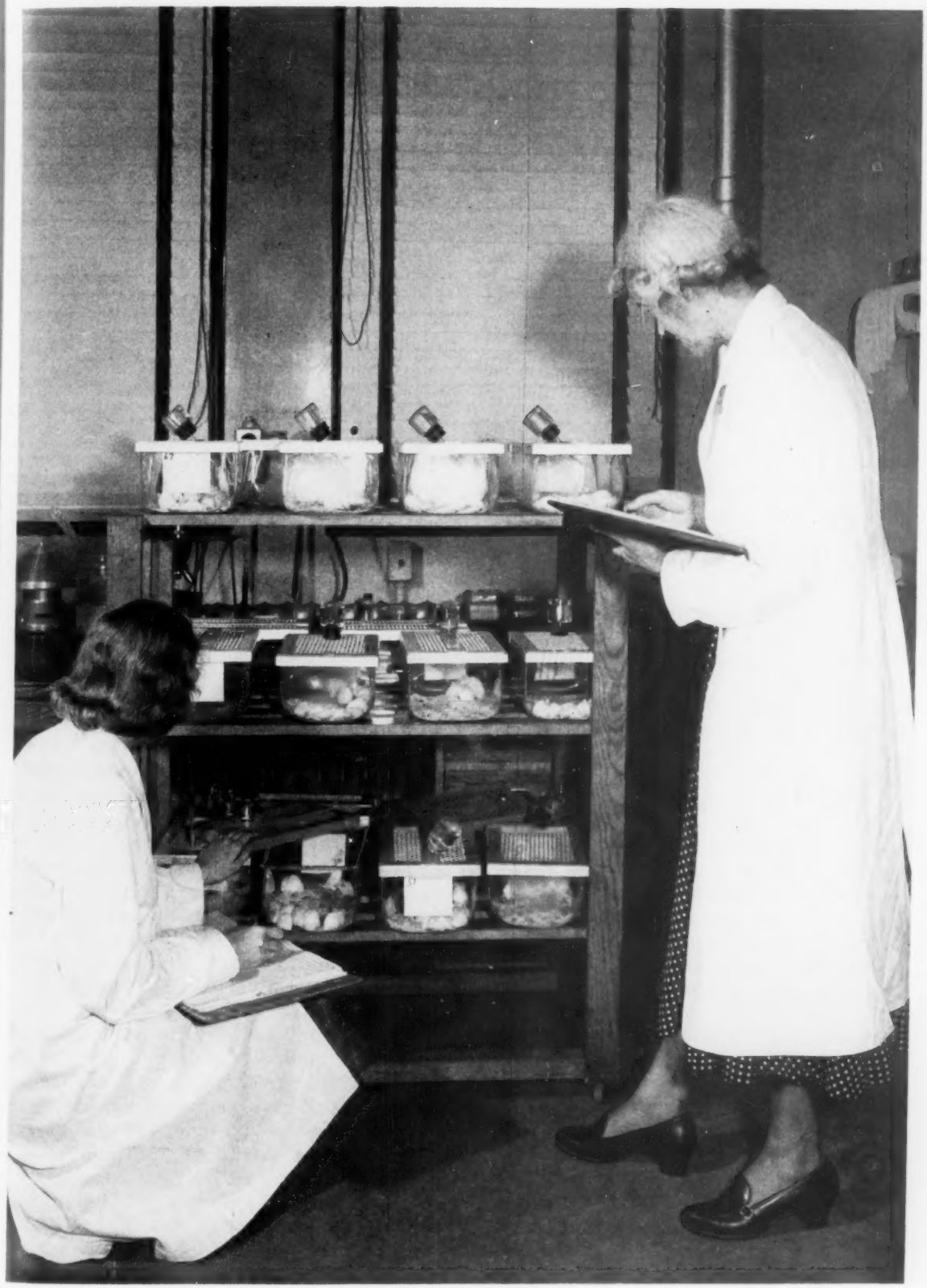
Another disease in which, astonishingly enough, good results from treatment with aureomycin have been reported is primary atypical pneumonia. This is an interesting disease, because at least as far as its recognition by physicians is concerned, it can be classed as a "new" disease. It was first recognized and described clinically in Hawaii, Texas, and Pennsylvania about fifteen years ago. It occurs sporadically and also in epidemics. It is a common ailment, is rarely fatal, but it can produce a disabling, painful, annoying illness. The best evidence points to a virus as its cause, but this viral agent has escaped characterization up to the present time. It is believed, however, that the virus of primary atypical pneumonia resembles those of lymphogranuloma venereum, psittacosis, ornithosis, and others that may produce pneumonic changes. Thus there was good reason to test the therapeutic effects of aureomycin in this disease. So far the results of treatment as reported from the Boston City, Presbyterian, New York, and Johns Hopkins hospitals have been excellent. When adequate, vigorous therapy is used, the temperature of the patient becomes normal within twenty-four to forty-eight hours, cough and pain in the chest disappear, the consolidation in the lungs resolves quickly, and in a short time the patient is cured. Thus, another disease for which no specific method of treatment existed prior to aureomycin is now amenable to therapy with this antibiotic.

Earlier, it was pointed out that aureomycin was effective in the test tube and in experimental infections in mice produced by various gram-positive and gram-negative bacteria. Its real range of activity against human infections produced by these microoganisms is not yet known, because, in most instances, treatment with the sulfonamides, penicillin, or streptomycin produced excellent results in these bacterial infections. For this reason, in the first year of the clinical testing of aureomycin, most of the available antibiotic effort was expended upon its evaluation in infections for which adequate and specific therapy was lacking. Evidence is in hand, however, that aureomycin has a specific effect in a considerable number of bacterial infections. It is excellent (although whether as effective as penicillin is another question yet to be decided) in certain streptococcal, pneumococcal, and staphylococcal infections. Currently, it would appear that in infections produced by Group D streptococci in the urinary tract, blood stream, or in the meninges, aureomycin is somewhat superior to penicillin in its therapeutic effects. On the other hand, in the treatment of gonorrhea, which is produced by a gram-negative coccus, penicillin is definitely superior. Reports concerning the use of aureomycin in infections produced by the meningococcus, such as epidemic meningitis or meningococcemia, are so scanty that outside of the fact that it has been demonstrated as being curative in a few instances nothing can be said.

In systemic infections produced by gram-negative bacilli, aureomycin, on the basis of present evidence, would appear to be relatively ineffective in those produced by Ps. aeruginosa (Pyocyaneous bacillus), P. vulgaris, and H. pertussis (whooping cough bacillus). It appears to be an excellent remedy for the treatment of systemic, localized, or urinary tract infections produced by coli-aerogenes groups of microorganisms. In tularemia (rabbit fever) the drug appears to be curative, as it does in infections produced by Kl. pneumoniae (Friedlander's bacillus). Its use in typhoid fever is questionable. There can be no doubt of its bacteriostatic effect against S. typhosa in the test tube, but sharply defined results from its therapeutic use have not been obtained in the treatment of typhoid fever, even though large doses were used. Little or nothing is known of its value in bacillary dysentery or in the treatment of acute food poisonings produced by microorganisms of the Salmonella group.

Experimentally, aureomycin has been shown to have a therapeutic effect in Weil's disease (a type of infectious jaundice). It also has some curative effect in syphilis, but the range of its use in this disease will take years to define. To begin with, in early syphilis, a considerable number of suitable cases will have to be treated and then followed carefully for at least eighteen months before its comparative value as a therapeutic agent can be initially assayed. Still, it is interesting that aureomycin has demonstrated some curative action in this infection.

The preferred way of administering this antibiotic is by mouth. Since it is produced as the hydrochloride salt, it is very painful and irritating when administered by the intramuscular or subcutaneous route. It can be given successfully by the intravenous method, but this way of using aureomycin is still in the stage of experimental development, and it remains to be determined just what the most satisfactory diluent for it will be.



Patricia Todd and Dr. Eleanor A. Bliss read results of a therapeutic experiment in a Johns Hopkins laboratory.

To date it appears unwise to inject the antibiotic directly into the spinal canal in the treatment of meningitis.

Not much is known about the absorption, distribution, and excretion of aureomycin when it is administered in curative doses to patients. This situation results from the fact that the exact chemical structure of aureomycin is still unknown, and there is no chemical test that can be used to detect it in the body fluids of tissues. One can get a rough approximation of how much of the antibiotic is in the blood, urine, spinal fluids, etc. by testing the ability of these fluids to inhibit the growth of certain microorganisms, but this biological method is very crude. Also, aureomycin deteriorates when in solution, and this again makes its accurate determination by biological methods difficult. In fact, there is no method of assaying this antibiotic which can be called quantitative in its results.

Another interesting thing about aureomycin is its apparent lack of serious or disturbing toxic effects. To date the only reactions reported from its use have been nausea and vomiting, and it is still not clear whether these side effects are produced by the antibiotic itself or by some impurity in it. In some patients, the nausea and vomiting have been severe enough to force them to stop taking the drug. Practically everyone who is given aureomycin develops some looseness of bowel movements, and in certain individuals diarrhea results. For this reason, it is believed that one should use caution in administering aureomycin to individuals who have colitis or irritable lower intestinal tracts. Again, the cause of this phenomenon is not completely clear. There can be little doubt that aureomycin suppresses the growth of intestinal bacteria, and this lack of bacterial activity in the gut may produce the large bulky stools noted by individuals who take this drug. On the other hand, however, this antibiotic may have some direct irritating action on the bowel. The interesting thing is that aureomycin, at least up to the time this is being written [April 1949], has not been reported as harmfully affecting the blood or blood-forming organs, the kidneys, or the skin. None of the disturbing toxic reactions that have been noted in the course of the therapeutic use of the sulfa drugs or certain other antibiotics have made their appearance to date in patients receiving aureomycin. Time may change this statement, but so far experience indicates that aureomycin is an antibiotic of low toxicity.

Finally, it would appear that infecting microorganisms do not develop resistance to the antiinfective properties of aureomycin at a rate comparable to that noted in the case of the sulfa drugs, or penicillin, or streptomycin. It is difficult by using current experimental methods to make microorganisms resistant in vitro to this antibiotic. The same is apparently true in so far as the etiological agents in clinical infections are concerned. This, then, constitutes another advantage, because one of the disadvantages, especially when streptomycin is being used, is that the infecting microorganisms frequently become resistant to its antibiotic effects.

The past fifteen years have witnessed revolutionary and extraordinary changes in our concepts respecting the prognosis and treatment of infectious diseases. Illnesses such as streptococcal meningitis, which formerly were almost universally fatal, are now rarely seen and are generally promptly amenable to treatment. A disease such as early syphilis, which previously required months, even years, of treatment, now appears to be cured in the majority of cases after a relatively few days of treatment with penicillin. In aureomycin, we have an antibiotic that can be given by mouth with a low instance of serious toxicity and with a curative effect in a wide variety of diseases. The lives of millions of people have been saved by the use of the sulfas and the antibiotics.

ABSOLUTE ELECTRICAL MEASUREMENTS

HARVEY L. CURTIS

After thirty-nine years of service with the Bureau of Standards, Dr. Curtis (Ph.D., Michigan, 1910) retired two years ago from his work as chief of the Interior Ballistics Section. His major scientific achievement has been in absolute electrical measurements, and his conclusions formed the basis for the United States proposals in establishing a fixed relationship between the absolute and international electrical measurement units at the International Electrical Congress last year.

SCIENCE is concerned with the prediction of the result to be expected when some known event occurs. In order to accomplish this, quantitative data must be available for all the pertinent factors that will be called into play when the event happens. Such quantitative data can be obtained only for those aspects of man's environment that are now measurable. The notable progress that has taken place in the fields of physics, chemistry, and engineering has resulted from the development of methods of measuring the most significant characteristics of physical objects. But basic measurements on living things are now being greatly expanded, profoundly influencing the biological and social sciences and hence playing an increasingly important part in such applications as agriculture, medicine, psychology, and economics.

In general, the making of a measurement involves a comparison between the object to be measured and some commonly accepted unit that can be used as a "measuring stick." The names of some of our familiar units of length and other simple quantities have come down to us from the days when the properties of easily available objects from everyday life were taken as standards. Of these, the "foot" and "stone" are still units of length and weight. The "watch" was once an important unit of time, but now is seldom used except on shipboard.

Mankind early discovered the convenience of combining units for the simpler quantities to obtain new units for related quantities. Thus, areas were measured by combining two units of length, and volume by combining three length units. It was also quite natural to express velocity in terms of length and time. The use of more complicated combinations of units did not begin, however, until comparatively recent times. The first step in the development of the modern units of physical measurement was taken in 1638 by Galileo, who expressed acceleration as velocity divided by time. It remained for Newton to show in 1687 that force can be measured as a product of mass and acceleration. The conception of energy as the product of force and distance, and of power as a time rate of doing work, took form slowly in the hundred years following Newton. Many men contributed to the development of these ideas, but Descartes and Leibnitz were perhaps the most outstanding. By the time these principles had become established, a complete system for measuring mechanical quantities had been evolved.

Meanwhile, the electrical units were being slowly developed during the first half of the nineteenth century. One of the first was the unit of capacitance, for which a Leyden jar of a particular size and shape was taken as a standard. When the telegraph was introduced in 1844, emphasis shifted to units of resistance and electromotive force. The resistance of an iron wire of specified diameter and length was at first used for a unit of resistance. When the resistance of such a wire was found to depend on the particular type of iron used, standards of copper wire were proposed; and when these were found to vary, a thread of mercury of definite size and length was employed. As a standard of electromotive force, a newly constructed Daniell cell made of high-grade materials was proposed at this time.

As a result of the contributions of Helmholtz and others, the principle of conservation of energy developed during the first half of the nineteenth century and by 1850 had become generally accepted. This made possible the extension of mechanical units to other fields of physics—such as heat, electricity, and magnetism—through consideration of transformations of mechanical energy into heat or into electrical or magnetic energy.

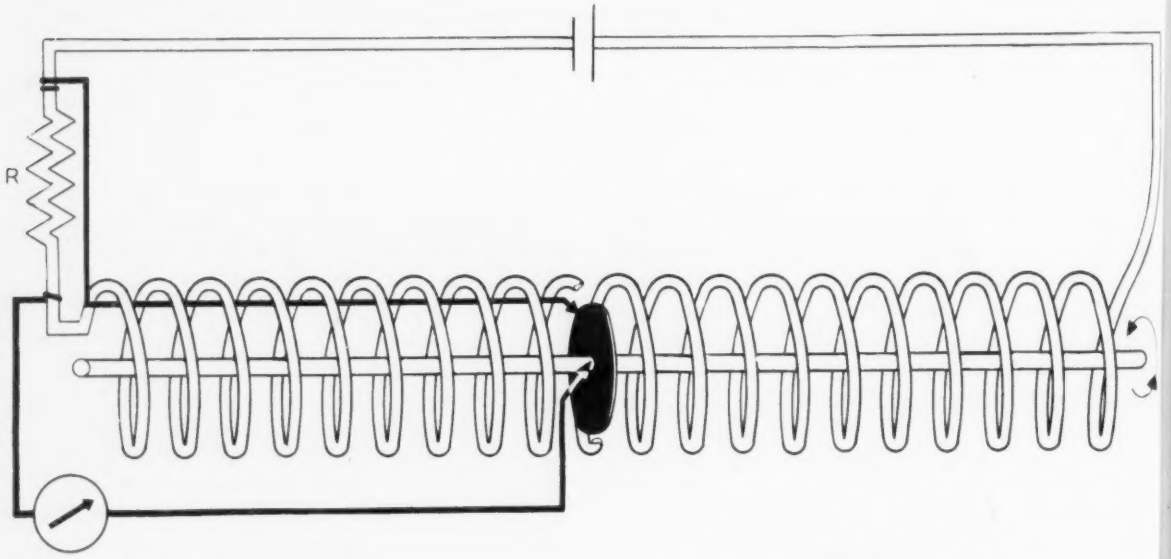
The possibility of basing the electrical units on a mechanical system of units was first demonstrated in 1851 by William Weber, who showed that this could be accomplished by accepting the principle of the conservation of energy and by assigning an arbitrary value—say, unity—to some electrical or magnetic quantity. If the permeability

of air (a quantity indicating the ease with which a magnetic field can be set up in this meidium) were fixed, the result would be an electromagnetic system of units. On the other hand, assignment of a value to the dielectric constant of a vacuum (a quantity indicating the ease with which an electric field can be set up in free space) would provide an electrostatic system of units.

It was nearly ten years later that this proposal was first given serious consideration. In 1860 the British Association for the Advancement of Science appointed a committee to consider the whole question of electrical units. This committee, which included Clerk Maxwell, Lord Kelvin, Joule, and others who later became famous, studied the several different proposals and eventually laid the basis for our present absolute system of electrical and magnetic units.

The British Association committee considered carefully the advantages of an arbitrary system of electrical and magnetic units. In such a system, two electrical units would be chosen for definition, and all other electromagnetic units could then be derived from them by relatively simple electrical measurements. The system of arbitrary units which met with greatest favor among committee members was based on units of resistance and electromotive force. The unit of resistance was to be the resistance of a thread of mercury one meter long and one square millimeter in cross section, maintained at the temperature of melting ice. For a unit of electromotive force, the e.m.f. of a Daniell cell made with highly purified chemicals and used under standard conditions was suggested. These defined units were then to be related to the mechanical system by careful electromechanical measurements that would give factors by which the mechanical effects of any electromagnetic phenomenon could be determined from measurements of the electric and magnetic quantities involved.

Although the arbitrary system of units had many advocates, it was finally rejected. Instead, the committee recommended a system of electrical and magnetic units based directly on the mechanical units and called this system an "absolute" electromagnetic system. The units of the absolute system are derived from the fundamental mechanical units of length, mass, and time by means of accepted principles of electromagnetism, with the permeability of space taken as unity. The com-



FORMULAS

$B = H = 4\pi I/p$

$E = \pi r^2 nB$

$E = RI = 4\pi^2 r^2 nI/p$

$R = 4\pi^2 r^2 n/p$

NOMENCLATURE

B	MAGNETIC INDUCTION
H	MAGNETIC INTENSITY
I	CURRENT IN HELIX
p	PITCH OF HELIX
E	INDUCED ELECTROMOTIVE FORCE IN DISC
r	RADIUS OF DISK
n	NUMBER OF REVOLUTIONS PER SECOND
R	RESISTANCE

FIG. 1. Diagram illustrating the Lorentz method for absolute measurement of the ohm.

mittee also sponsored experiments to develop suitable concrete standards of electrical quantities and to determine their values in absolute units.

In the absolute electromagnetic system, the units of electromotive force and current are defined in terms of mechanical units. Resistance, on the other hand, is defined by Ohm's law as the ratio of electromotive force to current in a circuit, a purely electrical relationship. Hence, if units of any two of these quantities are determined in terms of electrical or mechanical units, the third may be derived by an electrical measurement. In absolute measurements, resistance and current are usually measured directly in terms of electromechanical quantities, and electromotive force is then obtained by Ohm's law. For the standardization of electrical instruments, however, it is customary to establish units of resistance and electromotive force and then obtain current by Ohm's law. Thus, the role of the three primary electrical quantities in electrical measurement depends somewhat on the field in which they are to be applied.

ABSOLUTE VALUE OF THE OHM

A basic measurement in establishing the absolute system of units is the absolute determination of the ohm. At the time the British Association committee was at work, Maxwell developed a method of making such a measurement; his results were used for a quarter of a century, until more precise and simpler procedures were developed, of which the Lorentz and self-inductive methods are typical.

Lorentz proposed a very direct method of measuring resistance. A disk at the center of a helical coil carrying current (Fig. 1) rotates in a plane perpendicular to the axis of the coil. The magnetic field within the coil due to the current is perpendicular to the disk and can be computed from the dimensions of the helix and the magnitude of the current. The disk may be considered as an infinite number of filaments coinciding with its radii. Each of these filaments cuts the lines of magnetic force at the same rate, producing an electromotive force between the center and circumference of the disk. According to electromagnetic theory, the electromotive force thus produced is numerically equal to the rate at which the magnetic lines of force are being cut and can be computed from the magnetic field within the coil, the radius of the disk, and the rate of rotation of the disk. This electromotive force may be balanced against the fall in potential in a resistance R as the current from the helix flows through it. The electromotive force, expressed in terms of the current in the coil and various mechanical measurements, may thus be set equal to the fall in potential, expressed as the product of the current and the resistance R. Since the current appears on both sides of the equation, it cancels out, and the resistance is given in terms of mechanical measurements.

A modification of the Lorentz method was developed somewhat later at the British National Physical Laboratory. The apparatus, one-half of which is shown in Figure 2, is still maintained at this institution. It employs two disks mounted 1.7 meters apart on a long shaft. For each disk, there is a pair of short helical coils, one on either side of the disk, carrying an electric current which produces the magnetic field in which the disk turns. The four coils are connected in series, but the current in one pair of coils is clockwise, in the other pair counterclockwise. Thus the electromotive force induced in one disk is in the opposite direction from that induced in the other. As the disks are connected electrically, the external circuit is from the edge of one disk to the edge of the other. The disks are of such size that the magnetic field about their edges is approximately zero; hence, their diameters and thicknesses need not be accurately known.

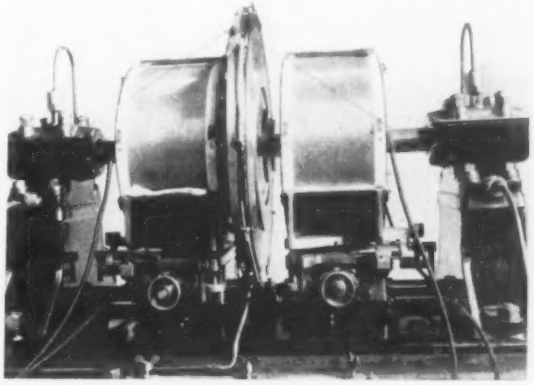


FIG. 2. Portion of the apparatus developed at the British National Physical Laboratory for absolute measurement of the ohm by a modification of the Lorentz method. An electromotive force is induced in the large disk (*center*) as it rotates in the magnetic field of the two coils on either side. A similar disk (*not shown*) is mounted between two coils on the same shaft at a distance of 1.7 meters from the first disk.

The electromotive force developed in the two disks by a unit current in the coils can be computed from the dimensions and positions of the coils, provided the permeability of all materials is the same as that of air. Resistance may thus be measured in

much the same way as with the earlier apparatus. This method is one of the most direct so far developed for the absolute measurement of electrical resistance, but it is difficult to apply because of thermal electromotive forces generated by sliding contacts at the circumferences of the disks.

The self-inductance method of determining resistance, first used by Greneisen and Giebe at the German national laboratory, has been refined at the National Bureau of Standards to the point where an accuracy of ten parts in a million is obtained. The success of this method requires the construction of a self-inductor whose inductance can be very accurately computed from its mechanical dimensions. Such an inductor was made at the Bureau by winding a helix on a threaded glass tube with a 3-inch wall.

The self-inductance method is an indirect procedure: it determines the correction factor that must be applied to an approximate value for a standard resistance in order to give an accurate absolute value. Three bridges are required: a Wheatstone bridge, an alternating-current bridge, and a pulsating-current bridge. The latter two are shown in Figure 3. The Wheatstone bridge is used to compare the resistances in the different arms of the other two bridges with the resistance of a standard resistor, the known approximate value of which is R. The resistances in the bridge arms are thus expressed as multiples of the resistance R. In the pulsating-current bridge, a vibrating tongue T charges and discharges the condenser C a certain number of times per second. When the tongue touches the upper contact, charging of the condenser begins, and a part of the charging current passes through the ballistic galvanometer B. When the condenser becomes charged, the current through the galvanometer is reversed and continues flowing in the reversed direction while the tongue moves to the lower contact and discharges the condenser. When the tongue again touches the upper contact, the cycle is repeated. The resistances (P, Q, S) in the bridge are varied until the average galvanometer current in one direction is the same as the average in the other direction. Then, because of the inertia of the heavy galvanometer coil, there will be no observable galvanometer deflection. The bridge is then "balanced," and the capacitance of the condenser is given in terms of the rate of vibration of the tongue and the resistances P, Q, and S.

The condenser is then transferred to the alternating current bridge, which uses a vibration galvanometer V (or perhaps a telephone receiver) as a detecting instrument, and the resistances of its branches are varied until the galvanometer reads zero at every instant. Then the inductance of the self-inductor is given as the product of the previously measured capacitance and the resistances R_1 and R_4. The exact value of the inductance may also be computed from the mechanical dimensions of the inductor. Thus a correction factor is obtained by which the inductance determined from the bridge measurements must be multiplied to give the value computed from mechanical measure-

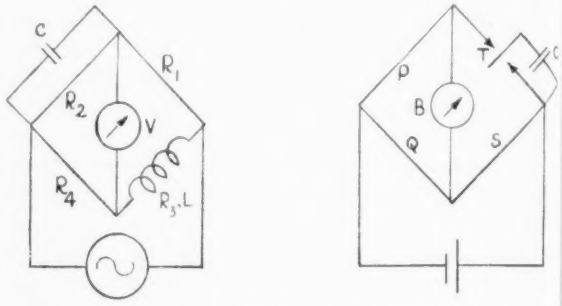


FIG. 3. Diagram illustrating the self-inductance method for absolute measurement of the ohm. In the a.-c. bridge at left, C is a capacitance; L is the self-inductor; R_1, R_2, R_3, and R_4 are resistances. In the pulsating-current bridge at right, C is the same capacitance as before; P, Q, and S are resistances; T is a tongue which vibrates n times per second. From the a.-c. bridge, $C=\frac{L}{R_1R_4}$; from the pulsating-current bridge, $C=\frac{Q}{nPS}$. Thus the measured inductance $L=\frac{QR_1R_4}{nPS}$. If Lo is the inductance of the self-inductor computed from mechanical measurements, then the corrected factor to be applied to each resistance is given by the ratio L/Lo.

ments. If all measurements have been carefully made, the discrepancy between the two values of the inductance can only be due to the small error in the approximate value R taken as the resistance of the standard. Hence, the correction factor determined for the inductance may now be applied to the value R to give an accurate value for the resistance of the standard resistor in absolute ohms.

The precision with which the absolute value of the ohm may be determined has markedly increased in recent years. The original determination by Maxwell was in error by more than one percent, but the most recent results by the self-inductance method do not differ among themselves by so much as two parts in a hundred thousand. This is perhaps the most precise measurement of any nonmechanical quantity in terms of mechanical units.

ABSOLUTE VALUE OF THE AMPERE

A current can be measured in absolute amperes by determining the very small mechanical force between two parts of the circuit in which it flows. Current is thus "weighed" at the National Bureau of Standards by means of the Rayleigh current balance, which measures the force between coils of wire carrying current (Fig. 4). In the center of two large fixed coils, a small coil is hung from the pan of a sensitive balance. When the three coils are connected in series, the force acting on the small coil per unit of current can be computed from the dimensions of the coaxial coils and their distance apart. (In practice the current is reversed in the coil attached to the balance pan, thus doubling the force per unit current.) The total force due to the current is found by adding or removing sufficient weights from the balance pan to restore the balance to its original position. This observed force divided by the computed force per unit current gives the current in absolute units. Changing of the weights, reversal of the current, and reading of the balance are accomplished by an operator in an adjacent room, separated from the balance by a glass partition.

The maximum variation in the results of the three most accurate determinations of the absolute ampere that have been made to date is a little less than one part in a hundred thousand. Although a larger number of independent determinations have been made for the ohm than for the ampere, this agreement is quite as satisfactory as that obtained for the ohm.

An absolute measurement of current is also used to determine the electromotive force of a standard cell in terms of an absolute resistance and an absolute current. Here the electromotive force of the standard cell is compared with the fall in potential which the measured current produces in a resistance whose value is known in absolute units.

PAST AND FUTURE OF THE ABSOLUTE SYSTEM

Although the concept of an absolute system of electrical units based on the mechanical units and the properties of a vacuum originated in the middle of the nineteenth century, the development of accurate measurement methods for obtaining concrete electrical units from this concept has been a slow process within the past hundred years. During this time there were several electrical congresses and conferences that gave consideration to the electrical units. They all reaffirmed the basic nature of the absolute system, yet each recognized the need of practical units to avoid the difficulty and expense of absolute measurements in the ordinary laboratory. Thus the scientific literature of this period contains results in the "British Association ohm," the "true ohm," the "legal ohm," and the "international ohm," as well as corresponding units for current, electromotive force, and other electrical quantities.

There was a feeling at most of these conferences that reproducible standards should be adopted so that any laboratory could easily prepare its own electrical standards. Eventually, the Chicago Electrical Congress of 1893 recommended an "international" system of electrical units based on this principle. The ampere was defined as that current which would deposit a given amount of silver in a stated time from an electrolytic solution; the ohm was defined as the resistance of a specified column of mercury; and the volt was given in terms of the electromotive force of the Clark standard cell. The international system was legalized in the United States by an Act of Congress of July 12, 1894; it also became legally recognized in most other countries.

As the years passed, however, two defects were recognized in the international system. First, as the demand for accuracy increased, the units were not sufficiently reproducible; and, second, three reproducible units were specified, whereas most laboratories preferred to use only two units, obtaining the third by Ohm's law. Thus, with the establishment of national standardizing laboratories in several of the larger countries near the beginning of the present century, the problem of maintaining the standard electrical units was entrusted to them. Any laboratory could have a standard certified in terms of the units of one of the national laboratories. But there still remained some differences among the standards of these na-

FIG. 4. Coils of the Rayleigh current balance used at the National Bureau of Standards for the absolute measurement of the ampere.

tional laboratories. To insure uniform electrical units throughout the world, the treaty of May 20, 1875 (known as the International Metric Convention and ratified by all civilized nations), was amended in 1923 to vest authority over the electrical units in the General Conference of Weights and Measures. Temporarily, the Conference took the international ohm and the international volt as the mean of the values of six national laboratories. Finally, on January 1, 1948, this system was superseded by the absolute system, incorporating the latest absolute determinations of the ohm and the ampere.

Although the definitions of the absolute units and the methods of fixing their magnitudes are different from those of the international system, the changes in magnitude were so small as to affect appreciably only measurements of high precision. For example,

1 international ohm	=	1.00049 absolute ohms.
1 international ampere	=	0.99985 absolute ampere.
1 international volt	=	1.00034 absolute volts.

As this is written, it seems improbable that any future modifications in the electrical units that may result from more accurate experimental determinations will be larger than two or three parts in a hundred thousand. Doubtless such modifications will be made if the results of future absolute measurements indicate a need for such a change.

DESERT RAIN

Through June the unvaried daily changes run
True to their sharply etched and classic form:
The blue-edged brilliance of the desert sun
Clips day from dark; the blazing silence ends
In chirping babble. Then the cold descends
Like perfume through the starlit quiet air,
Pervading every nook not blanketed.

As dew point rises, so the clouds begin
High over mountain, thunderhead and rim
Each day spread wider till the rains descend
From peak to slope and valley. Living things
Respond in floral torrent, insects swarm
While toad and reptile gorge against the norm
Of dust and heat in leaner days to come.

The day of riches over, plains return
To creosote and cactus (soft leaves burn).
Odd palo verde loses leafy fronds,
The dry arroyo holds mesquite alone,
And sharp against the evening sky are thrown
The flaming spikes of ocotillo wands.

Though lure of sand and sun and rock remain,
Most desert beauty lies in desert rain.

JOHN G. SINCLAIR

MAN'S SIX-LEGGED COMPETITORS

E. O. ESSIG

Professor Essig, who is chairman of the Division of Entomology and Parasitology of the University of California at Berkeley, has been with the University since 1914. Several of his articles on the history of science have appeared in this journal.

EVER since man first laid aside a few acorns, a store of seeds, some dried meat, and an extra skin to wear, insects have shared his thrift. The development of gardens, grainfields, orchards, pastures, and even forests has created much more favorable living conditions for the myriads of insects than would be available to them in a natural state. The growing of single agricultural crops in vast contiguous areas has made life for insects, feeding on each crop, easier in every respect; thus, in the production of wheat, corn, rice, cotton, apples, peaches, oranges, alfalfa, sugar cane, potatoes, and literally hundreds of other crops, man has bettered the circumstances of insect life. Never before in all the long history of the world have such extensive areas of luscious food been available to insects. The irrigation of immense semiarid regions, which under natural conditions could support but scant vegetation and sparse insect populations, has suddenly changed these barren wastes into Gardens of Eden for our small and versatile six-legged competitors.

In hotels, stores, restaurants, flour mills, food warehouses, and homes, insects have taken full advantage of the food and protection afforded them by man. In cold countries, the heating of human habitats during the winter has made it possible for a host of insects to continue their association with people where they could not otherwise have survived. Wherever man goes, the insects follow. Many of them have become his most devoted domestic animals.

In spite of man's claim to superiority over nature, and his so-called subjugation of the world, insects still haunt his person, his home, his fields, forests, and domestic animals. They have so far been inescapable. Because of their much longer sojourn on earth (more than 50 million years), their great numbers and kinds, their complex and efficient development, their ability to survive unfavorable weather, and their wide range of food, insects are apparently much better adapted to the exacting conditions of this world than man. It may well be true that the last surviving creature on earth will be an insect.

INSECTS AS PESTS

Insects contaminate as well as consume food products. In recent years, a great deal of attention has been given to the elimination of insects and their body parts, excrement, and webbing from all types of food products. Concerned in this endeavor are public-health authorities, entomologists, insecticide manufacturers, food processors, and canners. The most concerted action ever attempted is now under way to insure wholesome, insect-free fresh, dried, canned, and frozen fruits, cereals, and vegetables for the consumption of the public. New and more effective insecticides are being investigated and used by entomologists throughout the entire country and much of the world for this single purpose—the control and, in some cases, the complete eradication of insect pests.

Although insects exact a large toll of agricultural crops, they are a check on the overabundance of many plants and may serve as a balance to prevent the overcrowding of many noxious species of plants and weeds, and thus aid in the preservation of the very plants necessary for their own existence.

Many insects, such as termites and wood borers, aid in the rapid reduction of declining and dead trees and smaller plants, and thus contribute to their conversion into humus and food for other generations of plants. Plant-feeders in general furnish excrement and eventually their own bodies to aid in the supply of plant food. Thus insects are conservationists as well as consumers of plant life, just as is man.

Infestation of agricultural food crops by insects necessitates, for their control, the use of many insecticides that are incompatible with human health. To protect and preserve these crops in the fields, as well as in storage, it is extremely important that the entomologist exercise great skill

and good judgment in using only those means of control that will insure a reasonable margin of safety to human and animal consumers. There is a wide variation in the persistence and effectiveness of insecticides. A poison spray or dust that hydrolyzes or decomposes shortly after being applied may be effective in killing insect pests and lose its poisonous properties before the crop is harvested. Other, more stable, compounds may be employed on dormant fruit trees or upon very young plants, without danger to the health of the consumer. Still other sprays and dusts may be readily removed by washing. It is also important that all insecticides be free from unpleasant odors and taste and that they should not leave an offensive residue not easily removed.

Another device employed by entomologists to control injurious plant- and animal-infesting insects is biological control. By judicious liberation in sufficient quantities and at appropriate times, predaceous and parasitic insects may be used to destroy their objectionable relatives that are so destructive to man, as well as to his crops and domestic animals. Such insects are obtained by introduction from foreign countries or by artificial propagation in insectaries, and in this way the control of certain destructive insects may be accomplished wholly without the use of insecticides and their attendant dangers.

Those who are not familiar with all the intricacies of insect control are likely to be amazed at the prodigious problems that confront the entomologist, and the great amount of training, experience, and care necessary for the proper protection of foods from insect attacks and contamination on the one hand and for the employment of the many safety techniques for the protection of human health on the other.

INSECTS AS FOOD

Although insects are the commonest and most abundant forms of animal life associated with the human race, they are the least known and the most grossly misunderstood by even highly civilized peoples. Aboriginal races, however, apparently understood and appreciated the many values of insects; they used a great many of them for food and also ate various insect products, such as honey and honeydew as sweets.

I am especially desirous of calling attention to the fallacious belief that has generally been ingrained in most of us that insects such as aphids, caterpillars, and fragments of all other kinds are "filth." As a matter of fact, the minute, delicate, soft-bodied aphids, thrips, and the like, have throughout the ages been commonly eaten by human beings and other animals along with vegetables and fruits, without ill effects and no doubt even to the advantage of the consumer.

Aphids and other small species, which are common on nearly all vegetable crops, have in recent years caused great concern and much financial loss to growers and canners of spinach owing to the virtual impossibility of producing this crop without its being infested by some of these small and obscure insects, and thus subject to rejection or confiscation because of contamination by insects after canning or other processing. Even though repeated applications of insecticides are made and the harvested crop is thoroughly washed and otherwise treated to eliminate the insects, it is practically impossible to remove all their invisible parts from the canned product. It is even more difficult to process frozen vegetables that are entirely free from some of these microscopic insects. The fresh vegetables that the housewife procures directly from the home garden or from the market—though ever so carefully washed—probably contain many more insects than the frozen or canned vegetables, which are washed and cleaned much more thoroughly by machinery than they can possibly be in the household kitchen.

As a very small boy on the farm, I once inquired as to why black pepper was always applied to cooked cauliflower and was told that it was useful in covering any cooked aphids that may have escaped washing prior to cooking and that much resembled the small black specks of this well-known condiment. (I was also assured that the cooked aphids would not injure me in any way.)

In the long-time protection of the public health, is it better to allow people to follow the custom of our ancient and immediate ancestors in consuming harmless quantities of minute insects, or small parts of large insects that are normally associated with and contaminate food products, or to accept the alternative: the consumption of residual quantities of the numerous poisonous insecticides that are now being used to control insects—the use of certain of which has been made legal? The answer would seem to be an earnest attempt on the part of all of us to accept the least-hazardous procedure and to consider this difficult situation in as perfectly sane and reasonable a manner as may be warranted after adequate research.

This discussion would not be complete without some reference to the actual use and value of insects as food for man. Many species have been

consumed by all races, past and present. Examination of historical documents, including the Bible and numerous works on ancestral man, reveals the important dietary uses of insects. Our University of California anthropologists tell us that three fourths of the food of certain of our West Coast Indians was vegetable and one fourth animal, the latter of which consisted chiefly of insects.

Probably the most generally available and preferred insects the world over were locusts, or migratory grasshoppers. They often appeared unexpectedly from unknown lands in countless numbers, and, although in most cases they destroyed the local vegetation, including crops, they became food for hungry human beings. Local and migratory locusts were a regular article of diet to savage and civilized peoples in Asia, Africa, North and South America, Australia, and certain of the Pacific Islands. Even in recent years the abundance of grasshoppers in the Philippine Islands may be ascertained from their retail price in the public markets of Manila and other cities. Because grasshoppers are quite large and easily captured, they are readily available with little effort on the part of the laziest person. Dr. A. C. Baker, U. S. Bureau of Entomology and Plant Quarantine, writes to me as of July 28, 1948: "The market in the city of Oaxaca [Mexico] sells grasshoppers prepared for food. They are all ready to use and a sort of brownish red. They are quite good."

Many kinds of fresh-water insects are also consumed by both Eastern and Western peoples. In China and other parts of Asia the vast populations living on the banks and in houseboats on the lower reaches of the great rivers are favored during certain parts of the year by an inexhaustible supply of the large predaceous water beetles. They are consumed fresh, cooked, dried, pulverized in soups, and in other ways. Species eaten at the present time by the Asiatics include *Hydrous pallidipalpis* MacLeay, of North China and Tibet; *H. bilineatus* MacLeay, of South China and Indo-China; *Cybister bengalensis* Aubé; *C. guerini* Aubé; *C. japonicus* Sharp; *C. limbatus* Fabricius; *C. sugillatus* Erickson; and *C. tripunctatus* Olivier (Hoffmann, 1947). In China at the present time no less than fifty species of insects are not only consumed in the daily diet, but make up a considerable part of the total food intake. Some species are also considered to have unquestionable medicinal value.

The water bug known as the giant fish killer, *Lethocerus indicus* Stål, a preferred dietary item of tropical China, India, and Australia, attained a length of 4 inches. A similar water bug, *Lethocerus grande* (Dimmock), of South America, is even larger, measuring up to 4.5 inches; in North America *L. americanus* (Leidy), the commonest species, were and are still eaten by man.

In Mexico the water bugs (*mosco*), especially the Aztec water boatman, *Krizousacoria azteca* Jaczewski, the Mexican water boatman, *K. femorata* Guérin, and the commercial boatman, *Corisella mercenaria* Say, together with the Texcoco back swimmer, *Notonecta unifasciata* Guérin (Ancona, 1933), and their eggs (*ahuautle*) and young, occur in tremendous quantities in Lake Texcoco and Lake Chalco near Mexico City. They have been used for human food from ancient times, and are still so used in Mexico. They are also exported by the ton to other parts of the world, where they are sold for fish, turtle, and bird food. Concerning the use of these, Dr. Baker further writes: "The eggs of the water bugs are gathered, and you can make a sort of caviar out of them. I have a jar of them over at the house now. Here in the laboratory at the moment, I happen to have a paper bag full of the water bugs themselves which are sold in markets in some of the towns for chicken feed."

In California, the Indians of the Mono Lake region gathered and ate the pupae of the ephydrid fly, *Ephydra hians* Say, which were washed up in windrows on the shores of Mono Lake by windstorms. They are the size of kernels of wheat and are apparently very nutritious. Wild animals that ate them grew fat during the periods of their availability, or so it has been said.

The large fat grubs and also the pupae and adults of many beetles have been consumed fresh, dried, or parched. The most striking examples were those of the palm rhinocerus beetle, *Oryctes rhinoceros* (Linnaeus), of tropical Asia; the American sugar-cane beetle, or *grou-grou*, *Rhynchophorus palmarum* (Linnaeus), and the Hercules beetle, *Dynastes hercules* (Linnaeus), of the tropical Americas; and the giant atlas beetle, *Chalcosana atlas* (Linnaeus), of tropical Africa.

Of the caterpillars of butterflies and moths, all kinds were eaten either fresh, toasted, dried, boiled, or roasted. Hairy tent caterpillars of North America—especially California—which were abundant in the spring, were singed to remove the hairs and roasted before the fire by the Indians. The large larvae and pupae of the pine pandora moth, *Coloradia pandora* Blake, were dried and consumed alone or mixed with acorn meal by the aborigines of Western North America.

In Mexico City one of the delicacies often

praised by visiting tourists is *los gusanitos del maguey*. These are large white caterpillars that mine the fleshy leaves of various species of *Agave*. They are often offered for sale along with pulque. These caterpillars, or maguey worms, are usually fried; they are also canned and sold in grocery stores. The adult is a skipper butterfly scientifically known as *Acentrocneme hesperiaris* Kirby (*Aegiale kollari* Felder, *Teria agavis* Blasquez).

Termites have been an important food wherever these insects occur in tropical and temperate regions. All castes and states of them were eaten—mostly alive. The large queens of the mound-building species, occurring in tropical Africa, Australia, and elsewhere, were considered a very great delicacy.

Various species of lice infesting the bodies of humans were eaten by all aboriginal races. They were devoured not only because they had a pleasant "nutty" flavor, but also as a ritual among many people.

Countless other kinds of insects not only satisfied the appetite, but they also no doubt furnished the much-needed vitamins and other nutritional requirements of our ever-hungry ancestors. The recent discovery of vitamin F in fireflies, or lampyrid beetles, is but one instance of other valuable uses of insects.

In addition, insects furnished honeydew, the much-appreciated "manna" of the Israelites, and also honey, the most important sweet available up to about 1420, when cane sugar became a commercial product. The honeybee is probably the oldest animal domesticated by man. It was cultivated by the ancient Egyptians and Chinese, and, with the beginning of recorded history, this remarkable insect appears in the literature of all the important civilizations of the world. Many strains of the honeybee have been developed in different countries in the African-Eurasian continental areas. This important insect was unknown to the aborigines of the Americas and Australia, although there are small, inferior, stingless honey-producing bees in South and Central America. Until the time of Queen Elizabeth honey was the only readily available sweet and was used only by royalty, the clergy, and the upper classes.

Bristowe (1932) investigated the insect-eating habits of the Laos peoples in Siam and joined with them in eating many kinds of insects, spiders, centipedes, and other invertebrates. Of insects, the natives regularly ate the young and adult forms of grasshoppers, crickets, mantids, cockroaches, termites, dragonflies, moths, butterflies, beetles, weevils, ants, bees, wasps, and many others. Bristowe found most of them palatable and nourishing and liked many of them.

The total ash, or dry weight, of insects varies from 0.41 to 15.49 percent, there usually being more in the adults than in the larvae and pupae. The body chemicals include potassium, sodium, magnesium, calcium, zinc, copper, boron, aluminum, silicon, titanium, lead, phosphorus, arsenic, sulphur, chlorine, iodine, fluorine, manganese, iron, and nickel.

The *nitrogen* content of insects fluctuates during the development period and in the same insect may vary from 11.23 percent in the caterpillar to 8.81 percent for the pupae, and 10.49 percent for the adults by live weight.

The *protein* percentage in live weight varies from 13.22 percent to 17.13 percent.

Fats, which are the accumulating reserves, are very important components in the developing larvae and pupae of insects and may also constitute a major part of the adult body, especially the mature females. Silkworms contain 17.78 percent; their pupae, 43.43 percent; the moths, 24.21 percent; honeybee larvae, from 4 to 21.3 percent; and dry Melolontha beetles, from 10 to 11.5 percent.

Among the *carbohydrates,* glycogen is universally present in insects and may be very high: up to 31.1 percent in the larvae of the horse botfly, and to 33.48 percent in the larvae of the honeybee. Glucose is reported present in some larvae and is always present in adults. Sugar is found in small quantities in the blood.

Enzymes of various kinds are to be found in insects. Lipase, acting on fat, has been recorded from many orders. Cellulose, cytase, xylanase, inulase, diatase, glycogenase, dextrose, raffinase, melezitase, invertase, maltase, trehalase, lactase, glucosidases, formizyme, and others have been studied. Enzymes acting upon proteins and their derivatives, including coagulating types, rennet, proteases, trypsin, pepsin, erepsin, fibrin protease, fibroni, protease, asparaginase, haemolysius, and others, also occur in insects. In addition to enzymes there are also oxylases, tyrosmase, catalase, aldehydase, and zymase.

Important vitamins are found in insects, but these are not necessarily the same as those occurring in human beings.

Other reasons why insects must constitute an important source of nutritious food are indicated by the fact that many species of birds are able to rear their young only upon insects. Insects also are the chief food for many other land and aquatic

animals. Brues, in his *Insect Dietary* (Harvard University Press, 1947), indicated the value of insects as food for man in a somewhat different way: "Crude materials that are transformed into the bodies of our various food animals, especially fishes, and birds whose flesh later finds its place in culinary art."

INSECTS AS MEDICINE

Civilized and uncivilized peoples all over the world have employed insects for medicinal purposes almost as extensively as for food. Practically all those previously mentioned for culinary purposes were used for many real and imaginary ailments of the human body. In addition, many species that were not particularly palatable, and some that were downright horrible-tasting, were employed by housewives, conjurers, and doctors, often with surprising results.

INSECTS AS FILTH

There are a considerable number of insects that may justly be regarded as filth. All those species that live in manure, sewage, and other environments that may be sources of bad odors, tastes, and diseases should be so classified. Examples are cockroaches, earwigs, maggots of certain blowflies, flesh flies, botflies, warble flies, carrion flies, and dung flies. Others, sucking lice, bird lice, bedbugs, and fleas, are also obnoxious. The excrement of all insects and other objectionable products, such as spittle, webbing, offensive and poisonous glandular fluids, stinging hairs, and the like, may certainly be classed as filth.

Great masses of insects, however, are probably as nutritious and as wholesome as are oysters, crabs, lobsters, and even other types of meats ordinarily eaten by civilized human beings. Extensive investigations should be undertaken to explore the true value of insects as possible sources of food for the peoples of the world, as well as their possible harmful effects upon the human system if used in the dietary.

THE THEOBALD SMITH AWARD

After a lapse of five years, owing to the war, the Theobald Smith Award in Medical Sciences, established in 1936 by Eli Lilly & Company, will again be given at the Annual Meeting of the AAAS. Fellows of the Association should submit names of proposed recipients to Dr. Gordon K. Moe, Medical School, University of Michigan, secretary of Section N, with full information (in triplicate) concerning personality, training, and research work of candidates. The award will be $1,000 and a bronze medal, given for "demonstrated research in the field of the medical sciences, taking into consideration independence of thought and originality." An additional amount of $150 is available toward traveling expenses. The recipient must be less than thirty-five years of age on January 1 of the year in which the award is to be made and a citizen of the United States.

Past recipients are Robley D. Evans, Charles F. Code, Albert B. Sabin, Herald R. Cox, and Sidney C. Madden.

THE SCIENCE THEATRE

Scientific laboratories—academic, government, or industrial—or any organization having new and exceptional 16mm scientific motion pictures—either with or without sound—may arrange showings of their films at the Annual Meeting of the AAAS, New York City, December 26–31, 1949, by writing to

The Science Theatre
American Association for the Advancement of Science
1515 Massachusetts Ave., N. W.
Washington 5, D. C.

ORIGINS OF GEOLOGIC TERMS

FREDERICK A. BURT

Professor Burt (M.S., Chicago, 1929) is professor of geology at the Agricultural and Mechanical College of Texas, where he has been on the staff since 1921.

GEOLOGISTS whose basic undergraduate studies have been in liberal arts, and college students in the classical curricula who take geology as a science elective, are sometimes struck by the fact that geologic nomenclature has drawn much more heavily from the Greek than from the Latin roots and combining forms. Among beginning students the understanding of new terms is facilitated by an explanation of their basic meanings. As an illustration, a few days ago a class in Historical Geology was being introduced to the subject of Ordovician life. The term *Orthoceras* was explained as coming from two Greek roots meaning "straight" and "horn." The members of the class were then reminded of the mineral term *orthoclase,* with which they were already familiar, as being derived from the same root for "straight" combined with the root meaning "break," referring to the smooth right-angle cleavage of the mineral. Experience has shown that such explanations serve to fix attention upon some diagnostic characteristic of the object or process under consideration.

Among advanced undergraduates, whose training is usually technical rather than liberal, there is often a manifest desire to become acquainted with the inherent meanings of technical terms for the better appreciation of the thing for which the term stands. This is in part, perhaps, the expression of an unconscious desire for a touch of liberal learning. The greatest interest I have met has been displayed by my graduate students in the History of Geology Seminar. To these graduates the adoption of a name for a newly discovered feature or structure, or to apply to a newly determined process, is a vital part of the history of the subject. It is also a part of that intangible "academic knowledge" that is fascinating to even the most rigorously trained scientific mind.

Technical geologic terms may be grouped, on the basis of their origin, into five classes, as follows:

1. Terms that are adoptions and adaptations of words from the vernacular.

Such terms are more abundant, after excluding the names of formations and the specific names of minerals and fossils, than those of any other class. They come from all the important European and from many of the non-European languages. They occur most frequently as narrowly limited usages of English, e.g., *joint;* German, e.g., *graben;* French, e.g., *dune;* or Italian, e.g., *lava.*

Physical geography has played an important part in the establishment of such terms. This is especially true in geomorphology. The percentage of words from the French vernacular descriptive of glacial phenomena, such as *moraine,* is very high and reflects the early growth of glaciology in the Alps. The influence of the physical environment is shown again in the surprisingly high percentage of terms descriptive of aeolian processes and desert environments that have come from the Arabic, e.g., *hamada*; and from the Ural-Altaic group of languages, e.g., the Turkish *barchan.* Scientific explorers sometimes introduced such terms into the vocabulary from the languages of primitive peoples; for example, *nunatak* from the Greenland Eskimos.

The seventeenth- and eighteenth-century industrial backgrounds greatly influenced the development of vernacular-derived terminology in mineralogy and in physical geology as applied to mining. This is evidenced by such words as the English *fault,* the Cornish *gossan,* and the French *gangue* from the German *gang.*

2. Words created by changing a proper noun to a common noun or adjective standing for a type of phenomenon exemplified by the geographic feature which the proper noun designates.

Thus we have *meander* from the Meander River and *monadnock* from Mount Monadnock. This type of term formation is illustrated in paleontology by such fossil names as *Beltina* from the

Little Belt Mountains; in mineralogy, by *labradorite* from Labrador; in petrography, by *syenite* from Syene; in geomorphology by *monadnock*; and, in economic geology, by *artesian* from Artois.

The outstanding development of this type of terminology is seen in stratigraphy. This method of forming terms acquired great importance after the work of William Smith, who made it a policy to apply place names to formations such as his *Cornbrash* and *London,* from type areas in which the formations outcropped. Although the idea of stratigraphic place names did not originate with him, he deserves great credit for the impetus he gave to their usage.

3. Names given to geologic structures or materials for the purpose of honoring an outstanding member of the profession.

Such names are most common in paleontology, where a genus name is sometimes so formed—as *Murchisonia* after Sir Roderick Murchison—but more frequently in the formation of specific names—as *Oterceras woodwardi* for John Woodward. The method is occasionally seen in the construction of mineralogical terminology, as is evidenced by *wollastonite* for F. J. H. Wollaston. It is only in rare cases that we have a term in physical geology, as *louderback* in honor of G. D. Louderback, which originated in this way.

4. Words adopted by geological science from physics, chemistry, biology, and other sciences.

Such terms are especially common in mineralogy and paleontology. In these places they often make up the bulk of our nomenclature, as, for example, the chemical names in determinative mineralogy and the solid-geometry terms so common in crystallography.

These sciences have influenced geologic usage not only in the lending of their technical terms but also in the method of name formation. For example, paleontology has in the main followed the biologic method of drawing upon the Greek for genetic and the Latin for specific names.

5. Coined words.

We come here to those terms which have, from time to time, been coined from Greek and Latin roots and which have become established. To answer the question as to why there is this apparently great number of Greek as compared with Latin derivatives, I at one time attempted to arrive at some approximate ratio between the two. To accomplish this a list of words was set up, using as sources one of the standard college texts in each of the following subjects: physical, historical, structural, and economic geology. This list was supplemented by a search of the issues of the *Journal of Geology* and the *Bulletin of the Geological Society of America,* each for the years 1940 and 1941. Only words of obvious Greek or Latin root origin were listed, and all generic and specific names of fossils and names of minerals were excluded. All hybrid terms such as *metaigneous* and *peneplane* were omitted, the latter being a case in which the spelling has not been standardized (the controversy over *-plane* and *-plain* never having been settled to everyone's satisfaction). Such terms as *orogenic, orogenetic,* and *orogenesis* were counted as one, being considered as variants of the same word. Words merely cognate to others, however, were included. By this method it is believed as representative a cross section of the nomenclature was obtained as would be possible without much exhaustive study. Terms of Greek origin were found to make up 73.6+ percent, and Latin 26.3+ percent, of the whole. Although all sciences have numerous terms of both Greek and Latin origin, the superficial evidence, based on impressions rather than statistics, is that outside of geology there is no such preponderence of Greek-derived words as is here shown.

Studies in the history of geology have led me to adopt the viewpoint that this emphasis on Greek is due partly to the prejudices of some of the founders of the science. At the time geology was in its adolescence a great many British clerics were attracted to it as an avocation. Many of these men developed into professional geologists, and others made large contributions as amateurs. This period coincided in part with the English theological controversies culminating in the so-called Puseyism movement (after its later leader, the Rev. Edward Bouverie Pusey). The struggle was between High- and Low-Church Anglicism. The feeling that developed within the Low-Church element, to which these geologic clerics belonged, against both Roman Catholicism and the High-Church party was intense and included an emphasis on the original Greek origins of the New Testament and the conduct of services in the English vernacular in contrast with Latin masses and translations. This attitude was reflected in stress on the Greek classics and a prejudice against Latin origins of all forms. These theologically educated geologists, of whom William Buckland, William Conybeare, John Mitchell, and Adam Sedgwick were but four outstanding examples among many,

contributed much to geological nomenclature. It seems more than likely that the impetus given to preference for Greek over Latin in these early days of geologic science has continued down to our own times, not only through the carry-over of early terms, but also through the momentum toward Greek origins then established.

Something may be in order here concerning a considerable number of such terms as *drift* as applied to glacial deposits, and *Tertiary,* as a name for a stratigraphic system. These terms came into usage at a time when our interpretation of facts was such that their inherent meanings were believed to be appropriate. The advance of our knowledge has necessitated new interpretations, but the terms have stayed with us—with greatly modified meanings. They have thus become dissociated from everything suggested by their underlying meanings. Many attempts to replace such terms have been made, but in these and some other cases the words have become so firmly embedded in the nomenclature that replacement seems wellnigh impossible, and perhaps now inadvisable.

An occasional change in the diametrically opposite direction seems regrettable. Such a change is illustrated by the almost complete replacement of the meaningful English *boulder clay* by the less obvious Scotch *till.* The former term has been criticized on the basis of the fact that not all unassorted drift is a mixture of boulders and clay. No term, however, fits perfectly in its final analysis, and *boulder clay* has the virtue of inherent clarity throughout the English-speaking world. The general picture it presents of the variability of size range among its constituents is significant.

The field of etymology as applied to geology is a very small one, but it can serve as an interesting area of study capable of contributing many values to the science.

DUNES: MADE, UNMADE

Compounded of coral dust,
Of silica and dead seashell,
These gull-winged hills
Affirm the living matrix of their birth.

Like deer before the hounds,
They flee in frenzied flight
Before the wind and sea,
But fail to throw their scent.

Upthrusting in the mounting light,
Their winded flush gives way
To purple gasps, then pallor
As they trip, down-dip.

They roll and rise
To sounds of spray and air
Which warn of new assaults,
A never-ending chase.

JOSEPH HIRSH

EFFECTS OF MECHANIZATION ON AMERICAN AGRICULTURE

ROBERT T. McMILLAN

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THE mechanization of agriculture has been under way for hundreds of years, but it has broadened and accelerated greatly with the invention and use of the tractor. The process includes any shift from hand or animal power to motor power and any use of implements and machines in the operation of farms. Tractor-powered plows, planters, cultivators, and harvesters differ from horse-powered units in the degree of mechanization. Automobiles, trucks, stationary engines, and numerous other mechanical devices, whether power-driven or not, further increase the scope of mechanization.

What are the effects of the tractor and other farm machines generally upon American agriculture? This paper will summarize the major social and economic changes associated with increased farm mechanization during 1920–45 from analyses of selected census data for the United States as a whole, 67 randomly-chosen counties of the nation, and all 77 counties in Oklahoma. It is recognized that the social scientist cannot isolate completely the variable "farm mechanization" from other factors of farm technology nor identify precisely its cause-effect relationships, but he can approximate its concomitants within reasonable margins of error.

The method of study consisted of stratifying states or counties into groups according to the number of tractors per 100 farms as in Figure 1, and of comparing specified items between the longest time intervals—usually 1920–45—for which comparable data were available. The number of tractors per 100 farms was used as a measure of farm mechanization because its correlation coefficients with the average value of farm implements and machinery per farm were 0.89 for the United States, 0.92 for the 67-county sample, and 0.93 among counties in Oklahoma. This index was found to be more satisfactory than other measures which have been used or suggested, such as percentage of farms with tractors, number of tractors or value of farm implements and machinery per 1,000 acres of cropland, and frequency of trucks, automoblies, or electricity on farms.[1] Because of fluctuating dollar values, it is a more suitable index than value of implements and machinery. Generally, the findings were in agreement among the three areas studied, thus meeting the requirement of verification so essential to scientific research.

It should be kept in mind that the period included in this study was marked by violent economic fluctuations resulting from the deflation in agriculture following World War I, the general depression of the 1930s, the New Deal, and the second world war boom. Whether these uncontrolled factors limit the validity of the findings of this study can only be conjectured.

INCREASE AND DISTRIBUTION OF TRACTORS

First manufactured commercially in 1903, tractors numbered about 1,000 by 1910.[2] The number reported in the first census count in 1920 was 246,000. The census reported 2.4 million tractors on 34 percent of the nation's farms in 1945, and a preliminary estimate of the USDA indicated 3.2 million tractors on farms in January 1948.

Tractors appeared on wheat farms in the Dakotas and Montana before 1920 and thereafter spread rapidly through the Great Plains, Corn Belt, Lake, and Middle Atlantic states. The South has lagged far behind other regions in tractor use, owing partly to slow adaptation of mechanized methods to cotton production. Heavy losses of croppers and laborers since 1935, resulting from the crop-adjustment programs and alternative employment opportunities, have given impetus to farm mechanization in that region. Both the anticipation and the appearance of tractors on planta-

tions probably motivated many agricultural workers to seek employment in nonfarming occupations. Farm mechanization is now spreading more rapidly through the South than elsewhere, and this accelerated trend there probably will continue for several years.

FARM POPULATION

Decreases in farm population are associated with increased farm mechanization. Between 1920 and 1945, the rural-farm population of the United States decreased 25 percent. During the same period the median decreases among quartiles of states arranged in descending order according to number of tractors per 100 farms were: first, 29 percent; second, 25; third, 18; and fourth, 25. From 1925 to 1940, when the nation's farm population increased generally, losses were reported in 8 of the 12 states with the largest amount of farm mechanization.

The rural-nonfarm population increased proportionately less in the first quartile of states on the farm mechanization index than in the remaining states between 1930 and 1940. This suggests that there is less need for village and other rural-nonfarm people to perform services for the diminishing farm population.

Farm mechanization affects the age composition of farm population by reducing the numbers of children and persons in the younger working ages and, consequently, increasing the proportions of total population in the older ages.

Data to partially support this hypothesis are shown in Table 1. The percentage decreases in farm population from 1920 to 1945 generally were larger for each age group up to forty-five years old in the most mechanized farming states, and in Texas, Oklahoma, and New Mexico, than elsewhere. Other data show that gains in percentages of total population forty-five years old and older during the period were considerably greater among states most affected by farm mechanization. It is conceivable that mechanization, by easing the labor of farming, will lead to a longer earning life among agriculturists. On the other hand, it might enable farmers to retire at earlier ages than in the past.

The state-by-state changes in numbers of children under five for each 1,000 women fifteen to forty-four years of age in the rural-farm population between 1930 and 1940 show a slightly higher average reduction among the leading farm-mechanized states than among states in the remaining quartiles. Analysis of variance on changes in

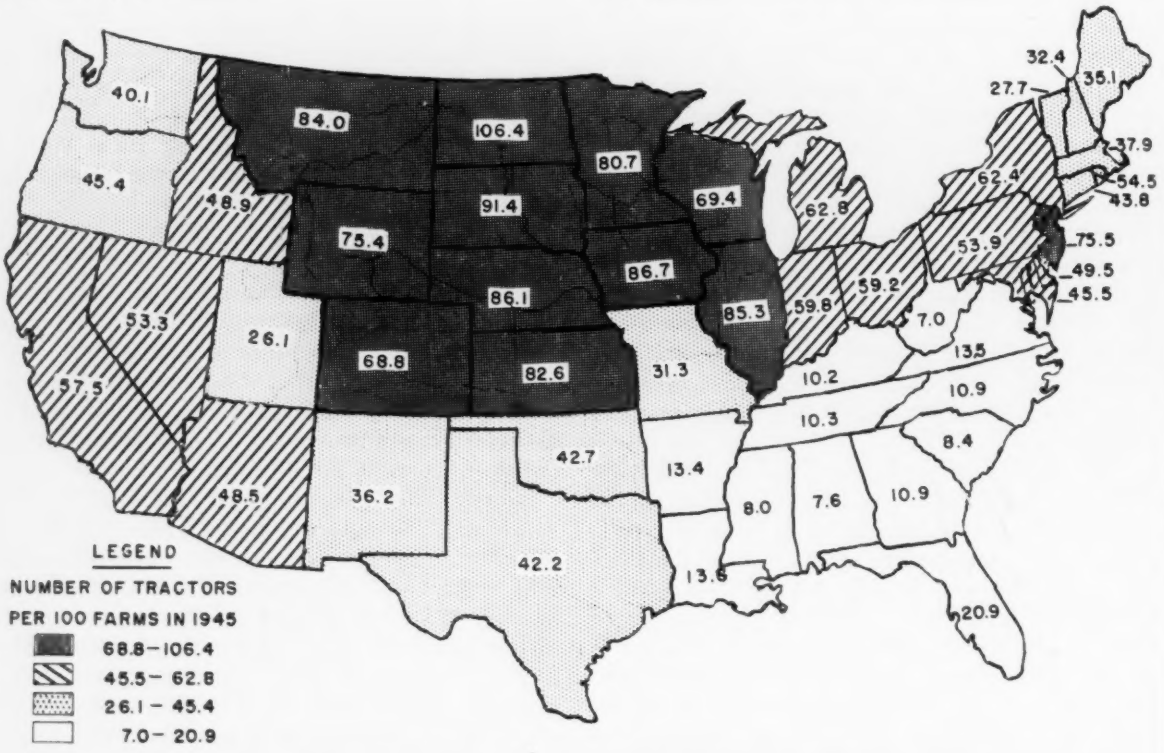

FIG. 1. Number of tractors per 100 farms, by states, 1945.

TABLE 1

PERCENTAGE CHANGES IN RURAL-FARM POPULATION WITHIN EACH AGE GROUP FROM 1920 TO 1945, BY STATES ACCORDING TO FARM MECHANIZATION INDEX

Farm Mechanization Group	Age Group, Years					
	All Ages	Under 15	15–24	25–44	45–64	65 and Over
All states	−23	−34	−39	−23	+ 9	+25
Quartile 1	−25	−28	−41	−28	+14	+37
2	−20	−30	−32	−24	0	+13
3 (nine states)	−13	−26	−36	−15	+17	+36
Texas, Oklahoma, and New Mexico	−33	−46	−53	−29	+17	+40
Quartile 4	−24	−33	−38	−19	+ 6	+20

these fertility ratios, however, reveals no significant differences among the several states owing to mechanization but highly significant differences owing to urbanization.

The greater reduction of nonwhite than of white farm operators was influenced little by farm mechanization up to 1945. The number of white farm operators in the United States decreased 6 percent, and nonwhite operators 27 percent, between 1920 and 1945. Relatively smaller losses of nonwhite farmers were reported in states with high tractor indexes than for the nation as a whole. Very few nonwhite operators reside in the most mechanized farming areas, however. In Oklahoma and Texas there were comparatively large reductions of nonwhite farmers, but, again, few such farmers ever lived in the mechanized portions. Other casual observations indicate that nonwhite farm operators have not been displaced or replaced in relatively larger numbers than white farmers by farm mechanization. Whether this situation will continue as farm mechanization becomes more widespread in the South remains to be seen.

NUMBER OF FARMS AND FARM TENURE

Decreases in numbers of farms are also associated with farm mechanization, and other factors are operating in the same direction. Although farm mechanization appears to be chiefly responsible for the displacement or replacement of farm families, crop-adjustment programs, alternative employment opportunities, and droughts led many thousands of low-income families to leave agriculture during the period studied.

The number of farms in the nation declined 9 percent between 1920 and 1945, although more farms were reported in 1935 than in other census years. The corresponding state-by-state decrease averaged 12 percent for the upper quartile of states on the tractor index. The trend toward fewer farms has been accompanied by two divergent tendencies: an increase in small part-time or subsistence farms, chiefly near cities, and an increase in large farms. Between 1920 and 1945, the number of farms in the nation with 500 acres and over increased from 217,000 to 287,000, a gain of 32 percent. The increase in the 12 states with the highest tractor indexes, though smaller relatively than for all states, accounted for 45 percent of all large farms added during the period. Another 29 percent of the total gain of farms with 500 acres and over occurred in the Plains states of Oklahoma, Texas, and New Mexico, where farm mechanization has spread rapidly in certain areas.

A direct relationship exists between number of acres per farm and number of tractors per 100 farms in each size group.

Changes in farm ownership and tenancy appear to be retarded by farm mechanization. Of all farms in the United States, 68 percent were owner-operated in 1945 as compared with 61 percent in 1920. Among the 12 states with the highest tractor indexes, there was less than one percentage point gain in the proportion of farms operated by owners. Larger gains were reported for all other groups of states. In the 67-county sample and in Oklahoma, increases in proportions of farms owner-operated were much smaller in highly mechanized farming counties than elsewhere during the period studied.

Other data disclose that share and share-cash tenancy strongly persists in states with the most farm mechanization. Cash tenancy and other forms of rental agreements have become increasingly popular in the less mechanized areas, though share tenancy still is most prevalent in the United States.

Census data fail to support the popular belief that farms operated by nonresidents are increasing

more rapidly in the states with the most mechanization.

Farm laborers probably have been affected more than any other tenure class by farm mechanization. The numbers of farm wage laborers in the nation decreased 29 percent between 1930 and 1940. The reductions varied directly with amount of farm mechanization, the most-mechanized farming states losing 41 percent. Although the definition of wage laborers and the age groups included in this occupational class differed in the two censuses, the data are comparable between areas.

Changes in numbers of farm operators working off the farm and in the time spent in this employment are responsive to farm mechanization. Relatively fewer farmers were employed in work off the farm in 1944 than in 1934, the reduction being much greater in the top 12 states on the mechanization index than elsewhere. Also, the number of farm operators working 100 days or more off the farm increased much less in the leading farm-mechanized states than in other states. During the 1930s many farmers supplemented low farm incomes with work off the farm; in the prosperous 1940s they were devoting more time to their farms, especially where units were becoming larger along with increased mechanization.

LAND USE

Increases in total acreage of farms and relatively small decreases in cropland acreage accompany farm mechanization. The greatest gains of total acreage in farms between 1920 and 1945 were made in states of quartile 1, and in the plains of western Texas and eastern New Mexico, where mechanized farming is widespread.

Total acreage of cropland in the 12 leading farm-mechanized states decreased less than in the remaining group of states from 1919 to 1944, and in the latter year accounted for 45 percent of the nation's total cropland as compared with 41 percent 25 years earlier. More land was under the plow in the Great Plains states, Kansas and Oklahoma excepted, in 1944 than in 1919.

Cultivable land has been shifted to those crops adapted to farm mechanization. The 12 states with the most farm mechanization had 59 percent of the nation's wheat acreage harvested in 1944 as against 57 percent in 1919. Corn rather than wheat is now the leading crop of the highly farm-mechanized states, with 51 percent of the nation's total acreage of this crop harvested there in 1944 as compared with 40 percent in 1919. In Oklahoma, the numbers of acres planted to cotton and wheat have declined precipitously in counties with the least farm mechanization and have risen sharply in areas where farm machinery is used extensively.

Increases in numbers of beef cattle, milk cows, and sheep were associated with increased farm mechanization during the period studied. Despite large decreases in numbers of horses and mules, the 12 states with the most farm mechanization, and Oklahoma, Texas, and New Mexico, had nearly as many "animal units" in 1945 as in 1920, and the average number per farm had increased absolutely and relatively more than in other groups of states.

OTHER FACTORS

Commercialization of farms is a concomitant of mechanization. In 1944, 90 percent of the farm products of the nation, by value, was sold, the remainder being used on farms. On farms in the upper half of states on the mechanization index, 93 percent of the farm products went to market. The trend toward sale of larger proportions of total products raised is accentuated by farm mechanization. Although commercialization of agriculture generally is considered favorable economically and socially, it does result in increased dependence of the farmer's welfare upon fluctuations of the business cycle and upon government, with subsequent loss of traditional self-sufficiency and autonomy.

Labor costs are reduced through use of labor-saving machines. Comparable census data on hired labor are available for the years 1924 and 1944. In the latter year the total amount paid for hired labor per 1,000 acres of land in farms of the United States was 174 percent higher than two decades ago. In the 12 states with the most farm mechanization, the corresponding increase amounted to 124 percent, indicating a savings in hired labor costs of nearly 30 percent. Competition for labor in the more urbanized states of the second quartile resulted in larger-than-average increases in cash expenditures for farm wage work there.

Analysis of data for 67 sample counties shows that cash costs of hired labor comprised the same proportion of the total value of all farm products in each of the two upper quartiles of counties in both 1929 and 1944. For the less mechanized farming counties, the ratio of expenditures for farm labor to total value of farm products increased between these censal years. In general, farm labor costs constituted a much higher proportion of all farm costs in 1944 than in 1929, owing in part to

the limited availability of such items as feed, fertilizer, and machinery in the critical war year.

Wealth and income. Farm mechanization correlates fairly closely with distributions of farm wealth and income. Stated in another way, adequate capital resources are a prerequisite of mechanization. Among all states, correlation coefficients of 0.65 and 0.64 were found between the tractor index and, respectively, the average value per farm of land and buildings in 1945 and average value of all farm products in 1944. These correlations were considerably higher for the 67 sample counties and Oklahoma.

Future analyses of farm mechanization may show that it results in geographical concentration of farm wealth and income. At present the evidence is inconclusive. The 12 states with the most farm mechanization accounted for a smaller proportion of the total value of land, buildings, livestock, and machinery in 1945 than in either 1920 or 1925. One reason for this is that the deflation of land values following World War I was most severe in the West and East North Central states where farm mechanization is general. The aggregate value of farm property increased in the second quartile of states but less than in the lower half of states on the mechanization index. Will history be repeated in the present readjustment period?

With reference to distribution of gross farm income in 1944 and 1929, the 12 states with the most farm mechanization accounted for exactly the same percent (35) of the national total in both years. In Oklahoma, data for the years 1929, 1939, and 1944 indicate concentration of farm wealth and income in counties with most farm mechanization but inconsistent results with reference to the second group of counties.[1]

There is a very definitely vertical concentration of wealth and income associated with farm mechanization. Within each quartile of states the ratio that the value of land and buildings on farms of 500 acres and over is of the total value of those assets on all farms increased between 1925 and 1945 as follows: first quartile, 56 percent; second, 53; third, excepting Oklahoma, New Mexico, and Texas, 49; and, fourth, 47. For the 3 states in the Southern Great Plains, the increase in this ratio was 88 percent.

Large production at high prices accounted primarily for sharp increases in farm income during the recent war and postwar boom. But farm mechanization also played an important part. The number of farms with farm products sold or used valued at $6,000 or over increased 231 percent between 1929 and 1944 in the 12 states with the most farm mechanization. The corresponding increase for the nation was 193 percent.

Level of living. The level of living of farm operator's families correlates closely with amount of farm mechanization. The coefficients of correlation between Hagood's level of living index for farm operators in 1945 and the tractor index were 0.70 for the United States, 0.67 for the sample counties, and 0.89 for the counties in Oklahoma;[3] however, the relative increases in proportions of farms with telephones, electricity, and running water in dwellings, and automobiles, between 1920 and 1945 were less in the 24 states with the highest mechanization indexes than in the remaining states. The incidence of these items is related more closely to degree of urbanization in each state than to mechanization.

Several possible reasons can be offered for the relatively slow improvement in levels of living of highly mechanized farming areas. The gains which might have been expected to accompany increased incomes from mechanized farms were not realized because, first, the recent transition to larger and more highly mechanized farms, owing to large capital outlays involved, may tend to retard a direct rise in the level of living; second, the cash costs of operating mechanized units may be so high as to reduce the *proportion* of total farm income available for family living, especially in periods of relatively low or falling prices for farm products; and, third, with rising price levels in recent years, farm families have been liquidating indebtedness on farms and chattels incurred during the depression of the 1930s. When the initial costs of farm mechanization and additional land purchases are paid off, possibly the relative amount of farm income available for family living will increase.

Farm families probably have more time for participation in leisure, religious, and other social activities as a result of mechanization. In Oklahoma, farm mechanization has facilitated consolidation of small country schools with village and city systems. The largest losses of these schools have occurred in that part of the state most affected by widespread use of the tractor and other farm machinery. Open-country churches have all but disappeared in those areas where the invasion of power machinery has displaced much of the population. This townward movement of schools, churches, and recreational facilities suggests that farm people, through increased contacts with vil-

lage and city populations, will become more urbanized in attitudes and behavior.

FUTURE OF FARM MECHANIZATION

Probably the nation is past midway in its farm power revolution, exclusive of possibilities relating to atomic energy. One authority predicts that by 1975 there will be 5 million farm tractors, other than garden tractors.[2] The continued invention of useful machines and implements, and increased electrification, should give further impetus to farm mechanization.

The diffusion of farm tractors and other machines into new areas may proceed more slowly than in areas already mechanized because of the following factors, if applicable:

1. Prevalence of relatively small farms and limited working capital per unit;
2. Greater density of population on farms;
3. Uneven to hilly topography;
4. Diversified or general farming, which sometimes is not easily adapted to use of tractors; and,
5. The plantation system, with its traditional dependence on comparatively cheap labor.

Farm mechanization has produced savings in labor, increased efficiency of farming operations, and resulted in greater productivity, consolidation of many uneconomic farming units, and improved levels of living among farm families remaining in agriculture. On the other hand, with mechanization have come a capacity to produce more food and fiber than can be consumed under effective peacetime demand, potential unemployment of agricultural workers, concentration of farm ownership among fewer landholders, increased social stratification of tenure classes, and depopulation of farms and villages, which are service centers for farmers. As yet, the full impact of farm mechanization has not been felt because of World War II.

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CANCER RESEARCH

A grant from the Atomic Energy Commission, through the Office of Naval Research, will enable the University of Delaware to continue research of potential significance in cancer control. Studies in progress in the Department of Biological Sciences, by Dr. Mary A. Russell, on the embryonic development of corn seedlings have revealed certain growth interference phenomena resulting from treatment with X-rays, neutrons, and mustard gas compounds. "The understanding of this interference upon actively growing cells," according to Dr. James C. Kakavas, chairman of biological sciences at the University, "will enhance our knowledge of the behavior of embryonic tissue to physical and chemical agents. These observations will have direct bearing on the cancer problem, since cancerous tissue simulates embryonic tissue development."

The Commission's grant is the third received by the University of Delaware in recent months. The other two were made by the American Cancer Society for a preliminary study of the effects of beta rays on living cells, a project directed by Dr. Harold Feeny, associate professor of physics.

THE APPROACH TO THE ABSOLUTE ZERO OF TEMPERATURE

JOHN F. ALLEN

A Canadian (Ph.D., University of Toronto) who has done research in low-temperature physics both in this country and abroad, Dr. Allen became professor of natural philosphy at St. Andrews University in 1947. His article is based on his inaugural addresss.

IN ALL the ages of recorded history, man appears to have striven for ultimates or extremes of qualities or quantities. At different times the striving has been for different things, but in the present age perhaps the greatest intellectual excitement has been manifest in the pursuit of the ultimate in knowledge of the physical world.

Among the more abstruse of these searches for the ultimate is the exploration to its farthest limits of that strange region of complete cold, where the perpetual St. Vitus dance of the atoms is stilled and where new and unforeseen phenomena which are obscured by the thermal agitation of the atoms at higher temperatures remain to be found.

If we want to put the St. Vitus dance in more pedantic language, we can say that heat consists in the random or disordered translational motion of atoms or molecules, and that the intensity, or the energy of that motion, is a direct measure of temperature; in fact, it is the definition of temperature. We stress the word *disordered*. Ordered molecular motion would simply appear as, say, a stream of gas or liquid. Such ordered motion represents energy which is capable of doing work, but it has no meaning from the point of view of heat or temperature. Temperature is thus a statistical concept, arising from consideration of the purely random and, in detail, unpredictable motion of the very large number of molecules usually present in any physical system which we are accustomed to contemplate.

Since temperature is a measure of the average random energy of a molecular assembly, we can fairly safely assume that there is no upper limit to it, for there is no reason to suppose that there is any upper limit to the kinetic energy which a molecule may possess. At the other end of the scale, we can conceive a definite limit. If the molecules are at rest, they obviously have no kinetic energy and therefore no temperature, and we can therefore define an absolute zero of temperature in such terms. Not only can we define such an absolute zero, but we can predict its position with considerable accuracy. Such a phenomenon is unusual in the physical world, and the absolute zero is in fact one of the few singularities, and probably the most important singularity, in nature.

The odd thing about the absolute zero is that, although we can calculate its position fairly accurately, so that we know where it is, we cannot and never shall be able to reach it, although we are able to get very close to it indeed. If we determine its position on the centigrade scale of temperature we find it at $-273.16°$, with some uncertainty in the last figure.

The centigrade scale is, of course, purely arbitrary, and it has now been replaced in physics by the absolute, or thermodynamic, scale, derived by Lord Kelvin, which properly gives the value zero to the absolute zero and therefore reckons all temperatures as positive.

If we examine the absolute scale of temperature, the first thing we notice—and it is obviously a trivial point since the scale extends upwards indefinitely—is that we are living at a temperature fairly close to the bottom—in fact, about halfway between zero and the melting point of lead.

The next point to which we must draw attention, and this is the crux of the matter, is that although it is relatively easy to move up the temperature scale, it is much more difficult to move down, and it becomes progressively more difficult the farther down we get. We cannot here illustrate both these statements directly, but the first is simple enough. If we strike a match, the comparatively small amount of work done in friction on the match head, combined with chemical action, produces at once a source of heat at a temperature of something like 2,000° absolute (K).

If we try, however, to achieve low temperatures by chemical action, say, by employment of the heat of solution, we could not get very far below the freezing point of water. To achieve lower tempera-

tures than this we must use purely physical means, and to attain really low temperatures, say, those of liquid hydrogen or helium, the apparatus must be quite bulky and powerful.

I

Why should it be so much more difficult to attain low than high temperatures? To understand the reason we must look again at the connection between temperature and the random motion of the atoms or molecules. Heating a body not only increases the energy of all its constituent particles, but it also increases the disorder in their motion. Conversely, if we cool a body, we diminish the energy and also—and this is really more important—we diminish the disorder in the system.

We give a name to the degree of disorder in a system. We call it the entropy, and entropy is a direct function of the temperature. We can illustrate this by means of a rather crude experiment. Suppose we have a tray containing white and red balls, which represent the molecules of a gas. Initially they are in a state of perfect order, but as soon as we shake the box, they begin to take up random motions and acquire a measure of disorder, and hence entropy. No matter how much or how long we shake the box, the balls are most unlikely to come back to their former ordered position. In other words, the probability of their coming back is small, or we may say that a disordered state is a highly probable one and is a state of high entropy. Furthermore, since any change anywhere in the universe is likely to take the form of the most probable one, then one can state a fundamental postulate of physics, that the entropy of the universe is continually increasing. This does not mean that the temperature of the universe is increasing, but that the degree of disorder is increasing since, although high temperature implies high disorder, high disorder does not necessarily imply high temperature. We shall enlarge on this point shortly, but meanwhile it might be instructive to ponder whether this fundamental postulate of a tendency to increasing disorder in the universe does not extend beyond the world of the physical into that of the sociological.

We see, then, that to lower the temperature of a body we must diminish its entropy. If entropy were a function of temperature only, we should never be able to attain any temperature lower than that our surroundings, but we have just mentioned that if such were the case it would imply a continually increasing temperature in the universe, which is absurd.

Luckily, the entropy of a system is a function of other things, of which one of the most important for our purpose is the volume. If we diminish the volume occupied by a given number of molecules we increase the order and hence diminish the entropy. One can see it in the following way. The degree of order can be expressed as the probability of finding a molecule at a given spatial position in a given volume. If the volume available to the molecule is reduced, then the probability of finding the molecule at the given position is increased, or, in other words, the degree of order is increased.

Since by doing a certain amount of work we can diminish the volume occupied by a given quantity of gas, we can therefore reduce its entropy. But, since the total entropy in the universe can never be reduced, the local reduction of entropy we have achieved must be balanced by a corresponding increase elsewhere. If we compress a gas, the "disorder" entropy becomes converted into "temperature" entropy, and the gas becomes hot. This heat can then be transferred to some cooling agent, say, a water bath. In thermodynamical terminology, we have removed some entropy from the gas and given it up to the rest of the universe.

If we now have the compressed gas back at room temperature, we can let it expand quickly so that it disorders itself in space once more. But it can only do that at the expense of its remaining "temperature" entropy, and in consequence the gas cools. The whole sequence is called the method of "external work," and if the process is repeated many times sufficient heat can be removed from the gas so that it liquefies. All the gases have been liquefied essentially by this means, and by this means we have been able to attain the temperature of boiling liquid helium at only 4° above the absolute zero.

These ideas and achievements were not, however, reached in a short space of time, and we must now go back into the past and see how man strove by speculation and experiment to understand the phenomenon of cold.

II

Robert Boyle was probably the first philosopher who so speculated and experimented, and to him the phenomenon was most puzzling. In 1682 he described some of these experiments to the Royal Society in a paper entitled *On Observations Touching Cold*. He discovered the refrigerating properties of an ice-salt mixture and observed that salts which did not dissolve in water produced no cooling. He observed the expansion of water when it

turned to ice and was mystified by the force with which the freezing water burst even strong iron vessels. Describing cold, he confessed that "he never handled any part of natural philosophy that was so troublesome and full of hardships."

Amontons, in 1702, discovered the air thermometer and conceived the idea of an absolute zero, where the volume of air in the thermometer would apparently vanish. He deduced the zero of temperature to be at what corresponds to – 240° C. He was ignored until in 1779 Lambert repeated his experiment more accurately and obtained a value corresponding to – 270° C, which he called the point of absolute cold.

There was some disagreement with this, and Lavoisier and Dalton did not admit that the gas thermometer was an absolute instrument. They tended, for reasons that are somewhat obscure, to put the absolute zero at what would be about – 3,000° C. It was not until 1848, when Lord Kelvin produced his celebrated treatise on the thermodynamic temperature scale, that the ideal gas thermometer was proved to be an absolute instrument, and the absolute zero fixed in the neighborhood of – 273° C.

As for the history of the production of cold, it is practically synonymous with the liquefaction of gases. Late in the eighteenth century, Cullen, teacher of Black, showed that the temperature of ether could be lowered by rapid evaporation, and early in the nineteenth century Leslie and Wollaston succeeded in freezing water by this means. In the early 1830s Faraday discovered that some gases would liquefy simply by compression at room temperature. If the pressure were allowed to fall over the surface of such liquids, then rapid boiling took place, accompanied by a drop in temperature. Using some of these gases as refrigerants while compressing others, Faraday, Davy, and Thilorier succeeded, between 1830 and 1844, in liquefying all the known gases except hydrogen, nitrogen, oxygen, carbon monoxide, nitric oxide, and methane. In this period the lowest temperature reached was – 80° C, with a mixture of solid CO_2 and ether.

In the 1860s and 70s the work of Andrews and Van der Waals showed that it would be possible to predict approximately the boiling points and critical temperatures of these gases that remained to be liquefied, and in the same period Joule and Kelvin published their famous paper on the cooling of a gas on passage through a porous plug. This phenomenon, where the molecules of a gas lose energy by what may be called the principle of internal work against their own attractive forces, has become one of the most powerful tools in the production of cold. All the remaining gases were liquefied by this means.

Within a fortnight of each other, and working independently, Pictet and Cailletet in 1877 announced the production of a few droplets of liquid air; but to Wroblewski in 1883 must go the credit for the production of the first liquid oxygen boiling quietly in a vessel, at a temperature of 90° K. Incidentally, Wroblewski started his career as a spectroscopist, but on being exiled to Siberia for some years by the Czar Alexander, he developed an interest in low temperatures. After his success with oxygen he tried for ten years to liquefy hydrogen, but in this he failed.

It was left to Dewar, who invented the glass vacuum vessel for the purpose, to produce liquid hydrogen in 1896 using the Joule-Kelvin process, first compressing the gas in contact with liquid air, and then allowing it to expand through a fine valve, where it partially liquefied at a temperature of 20° K.

More than nine tenths of the way to the absolute zero was thus covered, and the sole remaining unliquefied gas was helium. Observed first in the solar atmosphere in 1868, and then discovered by Ramsay in small quantities in certain minerals containing uranium, it was soon isolated in sufficient quantities for investigation. Olzewski and Dewar both made attempts around 1900 to liquefy helium by allowing it to expand from a pressure of 100 atmospheres and at an initial temperature of 20° K, but they had insufficient thermal insulation and the experiments failed. They did not then realize that the amount of heat required to vaporize 1 cc of liquid helium is about one six hundredth of the amount required to vaporize the same quantity of water. They were able to show, however, that they had achieved a temperature of less than 8° K.

It was Kamerlingh Onnes who, in 1908, first produced liquid helium boiling quietly in a flask. He had spent the previous ten years in detailed calculation of the expected properties of the liquid and in making his apparatus. Careful measurements, which he made on the isotherms of helium, indicated that it would have a critical temperature of between 5° and 6° K, (that is, the liquid could not exist above that temperature), and that its boiling point would probably be between 4° and 5° K.

He first cooled the compressed helium gas with liquid nitrogen and then cooled it further by means of a bath of liquid hydrogen boiling under reduced

pressure at 12° K. The gas was then expanded through a Joule-Kelvin valve, where it was further cooled and partially liquefied.

He determined the boiling point at 4.2° K, and the critical temperature at 5.2° K, and on almost the first occasion of liquefaction he tried to freeze the liquid by rapid evaporation. He lowered the vapor pressure to approximately 1 mm of mercury and reached a temperature of roughly 1° K, but produced no solid.

Thus only forty years ago a mere 1° of the 300°-odd down from room temperature remained to be covered. A fairly long pause ensued before any further lowering of temperature was achieved. The pause was a fundamental one, since no further gases remained to be liquefied, and so other means had to be sought to extract further entropy from matter. There was also the difficulty we have mentioned before. One of the fundamental laws of physics, the so-called third law of thermodynamics, states that the absolute zero is unattainable. It states, futhermore that the closer one gets to the zero, the more difficult it becomes to get closer still.

The twenty-year pause was, of course, only a pause in the search for lower and lower temperatures, and during that period there was a spate of research on the various new phenomena that were discovered at liquid-helium temperatures. The pause was also punctuated by one or two attempts further to reduce the vapor pressure and hence the temperature of the helium. In the middle twenties Keesom reached 0.7° K by attaching a series of great mercury diffusion pumps to a thimble-sized flask of liquid helium.

(It must be remarked at this point that such a low temperature as this is unique in the whole universe, since the radiative equilibrium temperature of interstellar space is in the neighborhood of 3° K.)

Since virtually all the entropy arising from the disordered motion of atoms and molecules has disappeared at 1° K, in order to achieve still lower temperatures we must seek some other and more subtle form of disorder from which we might extract entropy.

In 1926 Debye and Giauque, working independently, gave the hint as to where this disorder might be found. There is a group of substances which exhibit the phenomenon known as paramagnetism. Such substances only show magnetic effects when they are in the presence of a magnetic field, and therefore differ from iron in this respect.

Each ion in a paramagnetic crystal has what is known as an unbalanced electron spin, which means that the ion is in fact a little elementary magnet. Although the ions themselves are arranged in an orderly way in the crystal lattice, thermal agitation keeps the orientation of these ionic magnets in a completely random state, so that we have a species of subatomic disorder. The application of an external magnetic field will tend to turn all the ionic magnets in the direction of the field, and hence the magnetic disorder will tend to disappear, and the entropy will be correspondingly reduced. If the entropy can be reduced in this way, we might by suitable manipulation succeed in cooling a paramagnetic substance below the temperature of its surroundings.

At room temperature such an effect would be very feeble, but Debye and Giauque pointed out that by Curie's law the paramagnetism increases inversely with the temperature, and so at 1° K the effect would be three hundred times as great as at room temperature.

It was not until 1933 that successful experiments were performed both by Giauque in California and by de Haas in Leiden. The substance chosen was a rare earth salt, gadolinium sulphate, which was predicted to be suitable for the purpose. A specimen of several grams' weight was used. This was placed in a container in a bath of liquid helium at a temperature of about 1° K. The container also had in it an atmosphere of helium gas which could be removed by a vapor pump. When the apparatus was placed between the poles of a magnet and the field applied, the work done by the field in aligning the electron spins or ionic magnets, that is, the energy of magnetization, appeared as heat, according to the first law of thermodynamics. The salt therefore warmed up and was immediately cooled again by the atmosphere of helium which transferred the heat to the helium bath. Then when the salt was back at 1° K, the helium atmosphere was removed and the salt was thermally isolated. When the magnetic field was removed, the ordering agency no longer existed, and therefore the spins were free to disorder themselves. But now the only energy to do this could come from the crystal lattice itself, since none could come from outside, and therefore the substance cooled down below the bath temperature. The whole process is now known as magnetic cooling, or adiabatic demagnetization.

Although the earliest experiments achieved a low temperature something like 0.5° K, other, more suitable, and also less costly substances were quickly found, and with copper ammonium sul-

phate demagnetizing from a field of about 50,000 gauss, Ashmead in Cambridge in 1939 was able to attain a temperature of between 0.0015° and 0.003° K.

Of course, by this method the temperature drops quite suddenly and in one step, and then gradually rises again as the salt warms up to the bath temperature. There is no means at present of maintaining such a low temperature indefinitely. However, the relatively great contribution of the magnetic specific heat to its total specific heat is such that a specimen of salt may take ten or twenty hours to warm up from its lowest temperature to 1°K.

In an ideal paramagnetic substance in the absence of a magnetic field, the disorder would persist down to the absolute zero. That would mean, however, since we can remove the disorder magnetically, that demagnetization would take us right to the absolute zero itself, which is contrary to the third law. Actually, paramagnetic substances ultimately provide their own ordering processes, so that the low temperature limit with this technique is about 10^{-4}° K.

III

Such experiments as have been described have now been done many times, and the region of temperature in the neighborhood of 0.01° K is very familiar to low-temperature physicists. One might think, having got so close to the absolute zero, that we would be content, but of course this is not so. The region between room temperature (i.e., 300° K) and 3° K is relatively as spacious and full of interest as that between 3° K and 0.03° K, and the same is true of the region between 0.03° K and 0.0003° K.

What, then, is the next step? By perfecting present technique one might get down to 0.0003° K by removal of electron spin disorder, but that would be the limit. As far as we know, we are left with only one further important source of entropy of disorder, and that is in the atomic nucleus. The nuclei of many kinds of atoms are very feebly paramagnetic, and they also obey Curie's law; that is, their nuclear paramagnetism varies inversely with the temperature. The effect is inappreciable at room temperature, and it can only be observed with some difficulty at 1° K. But at 0.01° K it is quite pronounced. If one could first cool a suitable substance, say, a compound of lithium, down to 0.01° K in the presence of a large magnetic field of about 100,000 gauss, then demagnetization under such conditions would give one a reasonable chance of reaching a temperature of 10^{-5}° K or 10^{-6}° K.

Can this be done? We don't know, but experiments are already in progress in Cambridge to find out. The apparatus may be roughly described as follows. A large cylinder of some paramagnetic salt, say, copper or ferric sulphate, is fixed at the upper end of a metal rod six or eight inches long. At the lower end of the rod is fixed the nuclear substance, say, lithium fluoride. The rod with its two appendages is in a container in a helium bath, and both are in the presence of a very large magnetic field. The magnet is slowly lowered so that first the sulphate comes out of the field and is demagnetized, and its temperature—and by conduction that of the nuclear substance—is lowered, and cools to the region of 0.01° K. The magnet is further lowered so that now the nuclear substance is demagnetized, this time from a starting temperature of 0.01° K. Whether the experiment will be a success should be known within the next year or two.

It would appear from all that has been said that we are really getting very close to the absolute zero. So we are, in one sense, but it is instructive to look at a temperature scale plotted logarithmically instead of linearly, as is normally done. One can see on such a scale of temperature, which is the only satisfactory scale to picture at these very low temperatures, that the absolute zero has receded to minus infinity, where in fact it has always really been, and where it will remain, unattainable.

IRRIGATION AGRICULTURE ALONG THE NILE AND THE EUPHRATES

FRANK M. EATON

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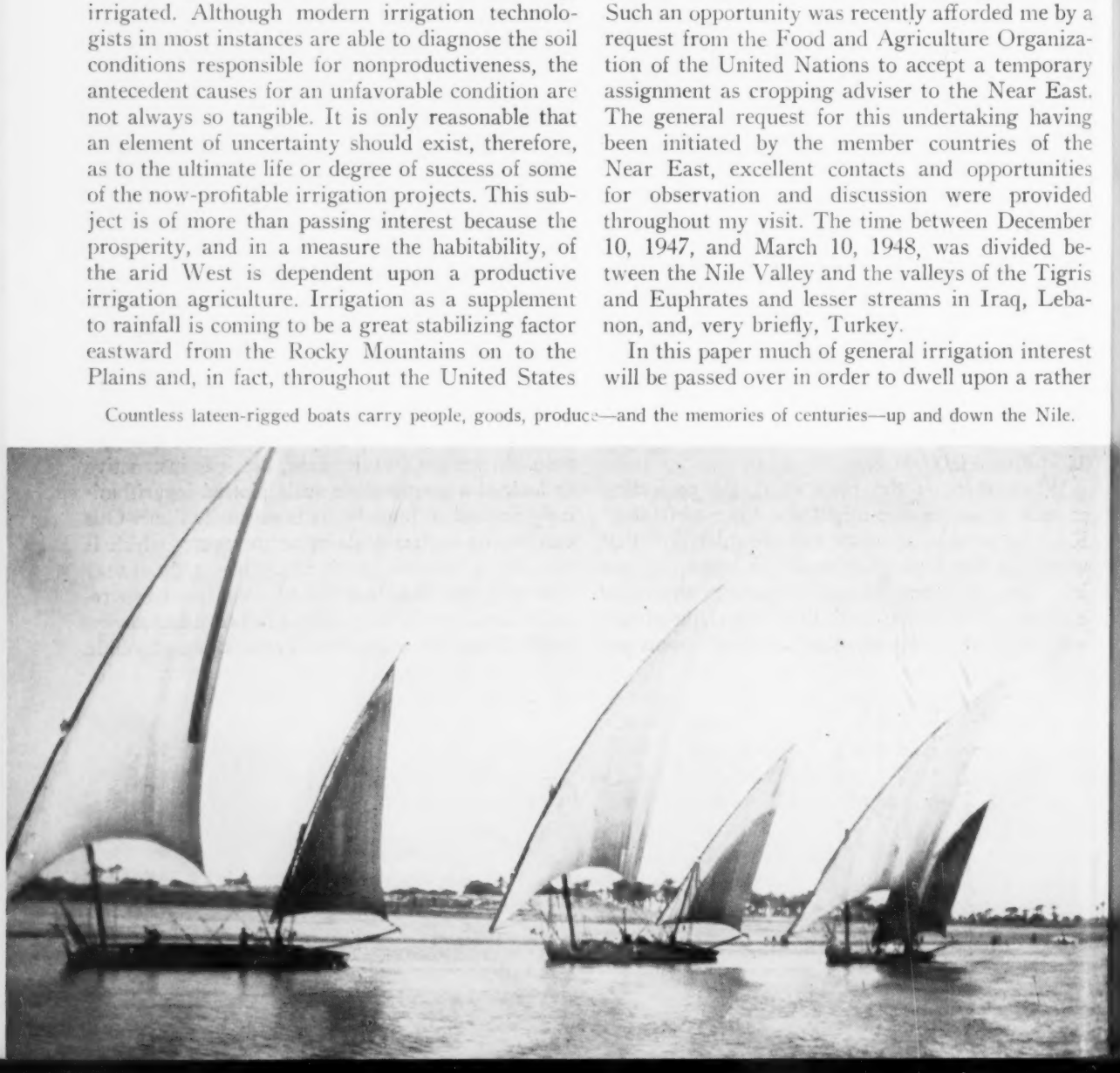
STUDENTS of irrigation, as well as laymen, have sometimes voiced questions regarding the permanence of irrigation agriculture. Such questions are natural because of the failure or low productivity of a good many soils in the United States which have been, or are currently, irrigated. Although modern irrigation technologists in most instances are able to diagnose the soil conditions responsible for nonproductiveness, the antecedent causes for an unfavorable condition are not always so tangible. It is only reasonable that an element of uncertainty should exist, therefore, as to the ultimate life or degree of success of some of the now-profitable irrigation projects. This subject is of more than passing interest because the prosperity, and in a measure the habitability, of the arid West is dependent upon a productive irrigation agriculture. Irrigation as a supplement to rainfall is coming to be a great stabilizing factor eastward from the Rocky Mountains on to the Plains and, in fact, throughout the United States wherever summer droughts occur and water is available.

To anyone who has long been concerned with the effects of mineralized waters on soils and plants, it is a natural desire to observe at firsthand the conditions in the world's oldest irrigated lands. Such an opportunity was recently afforded me by a request from the Food and Agriculture Organization of the United Nations to accept a temporary assignment as cropping adviser to the Near East. The general request for this undertaking having been initiated by the member countries of the Near East, excellent contacts and opportunities for observation and discussion were provided throughout my visit. The time between December 10, 1947, and March 10, 1948, was divided between the Nile Valley and the valleys of the Tigris and Euphrates and lesser streams in Iraq, Lebanon, and, very briefly, Turkey.

In this paper much of general irrigation interest will be passed over in order to dwell upon a rather

Countless lateen-rigged boats carry people, goods, produce—and the memories of centuries—up and down the Nile.



outstanding relation found in two of the countries visited between the occurrence of black alkali in soils and the presence of residual sodium carbonate in irrigation waters. By residual sodium carbonate is meant the sodium carbonate reported as such in the old-fashioned procedure of recording analytical data in hypothetical salt combinations; a procedure which was outmoded by the development of concepts of ionization. Beyond the subject of black alkali there will be some discussion of the trend of events in Egypt and Iraq as they have been influenced by the salts of the irrigation waters. A renewed recognition of sodium carbonate in irrigation waters as a factor in black-alkali formation should provide for a little more inclusiveness in water quality appraisals and, thereby, for increased foresight into things that may lie ahead in a number of irrigation enterprises. Here and there the formation of black alkali has continued to be one of the most difficult features of irrigation agriculture —not only from the standpoint of understanding its cause and mode of formation, but also from that of its avoidance and the reclamation of the affected lands. Black alkali, as is generally known, is the descriptive name applied to soils that show an alkaline reaction in the range of about *p*H 8.4—10 or more. With increasing alkalinity in this range, organic matter of the soil is brought into solution, and, because of it, the soil takes on a dark-brown to blackish appearance. Black-alkali soils may or may not be saline, but they are rather impervious to water movements; i.e., under the influence of the absorbed sodium the soil's granular structure breaks down and the individual soil particles become dispersed and subject to packing. Although much work has been done on the chemical and physical properties of black-alkali soil and its reclamation, an antecedent cause in the chemical characteristics of irrigation waters has generally escaped attention since the time of Hilgard and Stabler at the turn of the century.

The waters of the Tigris and Euphrates in Iraq and of the Nile in Egypt have been used for many centuries as a basis for the agriculture supporting two great civilizations. One cannot say accurately just how long these civilizations have been depending upon irrigation, but it is well established that during recorded history the Nile Valley of Egypt and the lower stretches of the Tigris and Euphrates valleys in Iraq have been far too arid to have supported farming without irrigation. The annual rainfall at Bagdad and Basra in Iraq is about 7 inches. Cairo receives less than 1.5 inches annually, and Aswan, which is in upper Egypt, is within the so-called rainless belt.

Reworking the land with wooden plow in northern Syria.

Life seems simple in this village near Basra as seeds are spread to dry.

The *Sakia*, with its endless chain of water pots and endless groaning and squeaking, may be operated by ox, horse, camel, or donkey. Animal is usually blindfolded so that he does not become dizzy.

In his book *Twin Rivers*, Seton Lloyd (1947) concludes that the beginning of the first dynasty of the Sumerian Kings of Iraq, almost exactly three thousand years before Christ, corresponded in time with the first Egyptian dynasty. This was the beginning of history in terms of countries ruled by kings whose names are known. As he says,

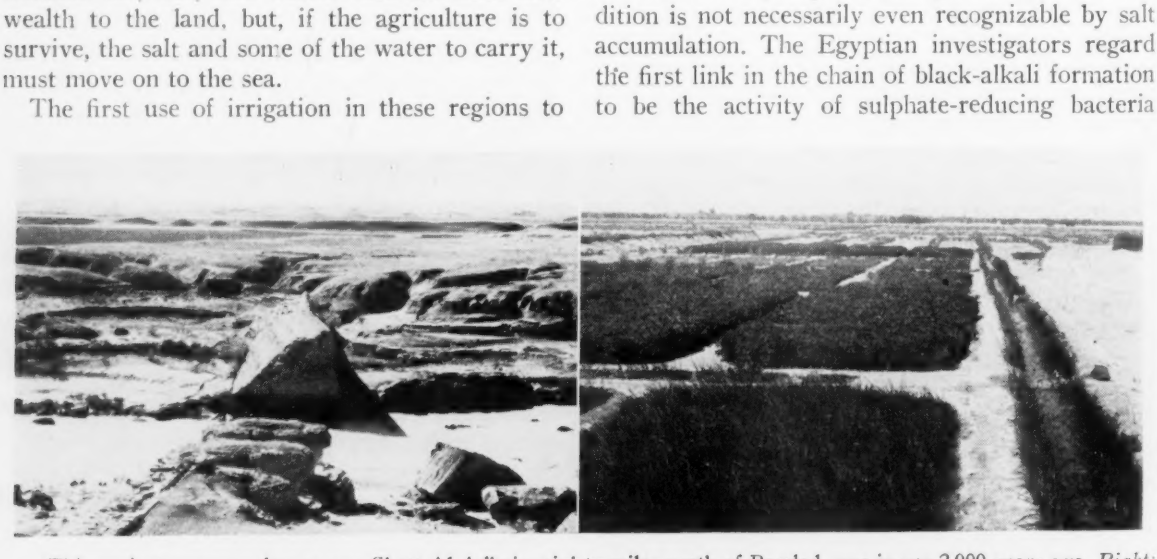
> Everything before this is more or less convincing speculation, arising out of the results of archaeological researches. In the case of Iraq, some of the most striking material which excavations have produced belongs to the dark period before written records begin, and any history would therefore be incomplete without an initial discussion

of it. The first conclusion to which an old-fashioned archaeologist reluctantly comes is that Mesopotamia is not the "Garden of Eden," either Biblically or figuratively speaking. The ancestors of the first human beings who settled in Iraq in any numbers had, for hundreds if not thousands of years, been living in houses and known the use of comparatively advanced conveniences, such as pottery.

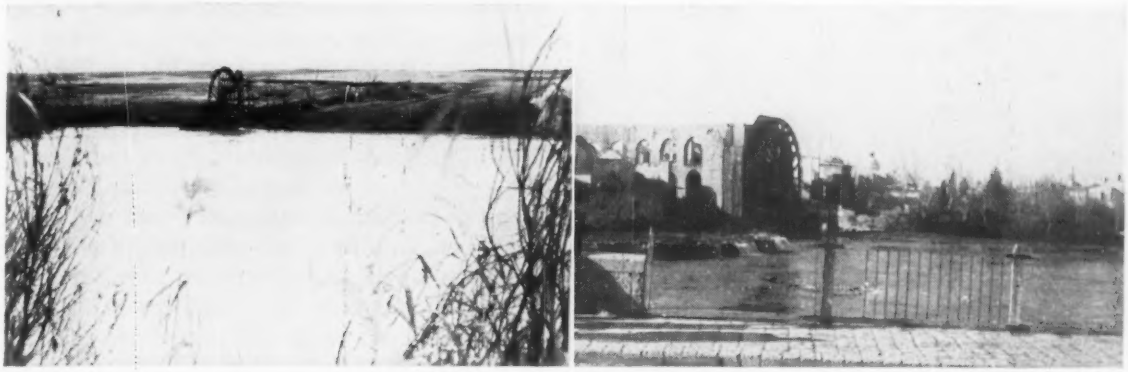
The length of time a particular parcel of land in either of these countries has been irrigated must remain conjectural. As a consequence of floods and water diversions, silt is still being deposited and the soils deepened in the valleys of the Nile and the Tigris and Euphrates. The Nile mud varies from a depth of about twenty feet in the valley to forty feet or more out on the delta. One figure for the rate of silt deposition along the Nile is a twentieth of an inch per year. At such a rate, the surface soil of a thousand years ago is now four feet below the present surface. In Iraq a similar heavy deposition of alluvium has been going on. The geologists know, for example, that the Persian Gulf at one time extended well north of Bagdad, or nearly three hundred miles inland from its present head. Both in Iraq and in Egypt the building of the alluvial valleys has progressed through the centuries. The older soil, which is now covered, can nonetheless, by its permeability, affect the course of the agriculture in the overlying soil. But, like the waters that loosened the soil particles and bore them to the valleys, the upper and lower alluvial depositions are, by and large, of the same genesis. The watersheds have continuously contributed silt, salt, and water. The silt adds new wealth to the land, but, if the agriculture is to survive, the salt and some of the water to carry it, must move on to the sea.

The first use of irrigation in these regions to support the growth of planted crops was not in keeping with the meaning we attach to the term irrigation here in the United States. We regard irrigation as consisting of applying water to land or to growing crops by diverting or pumping it from rivers, lakes, or underground aquifers; a system of ditches or pipes is usually involved. Actually, the first use of stream waters to supplement rainfall was not accomplished, probably, by diversion but rather by planting seed promptly after the subsidence of flood waters. Following the recession of the Nile, I observed while at Luxor, Egypt, the fellahin rubbing seed of lentils and barley into slippery soil with their hands after its surface had been roughly scratched. The construction of diversions and ditches to carry water to the land, like the various primitive devices for lifting water, have come later than the primitive practice of planting on flood-wetted soil. In lower Iraq, one form of primitive irrigation was probably similar to the present subirrigation near the Persian Gulf; the land is networked with ditches, which fill and drain with the rise and fall of the river as its water is backed up by the tides.

In Egypt, black alkali constitutes one of the major soil problems, whereas in Iraq black alkali does not occur—or at least not in the great valleys of the Tigris and Euphrates. In Egypt the existence as well as the formation and spread of black alkali, and with it the partial or complete loss of productive capacity in the most affected spots, is characterized by impermeability to water. The condition is not necessarily even recognizable by salt accumulation. The Egyptian investigators regard the first link in the chain of black-alkali formation to be the activity of sulphate-reducing bacteria



This ancient masonry dam across Shatt Al Adhaim eighty miles north of Bagdad, was in use 2,000 years ago. *Right:* water too salty for long use on the same land, is lifted from open wells in goatskins. First plantings are vegetables, but when irrigation is started little cuttings of the salt-tolerant tamarix are pushed into the soil. Their roots go down to the ground water. After the third year, there are crops of wood to be cut and sold in Az Zuhair or Basra. Except for these plantings (*see background*) and the dates along the riverbanks, the delta is dry, flat, and barren.



Primitive water wheel on the Khabour in northern Syria. This wheel, run by the current of the river, discharges water from cans on its rim into trough and irrigation ditch. At Homs, Syria, another great water wheel spills water into an ancient aqueduct.

brought about by the rise of the water table. They list the differences between the alkali and surrounding fertile soil as a predominance of absorbed sodium, a heavy increase in precipitated calcium carbonate and magnesium silicate, a great reduction in organic matter, an abnormally high carbonate-bicarbonate titration of the water extract, a high silica content of the clay which becomes retentive of water and difficult to dry, and an often-present black skin of organic matter on the surface of the soil, giving rise to the term black alkali, or *Armout*.

Because it has accentuated the drainage problem, the extension of perennial irrigation through the use of the increasingly elaborate system of diversion dams (barrages) and canals has made the formation of black alkali more serious in Egypt; corresponding with the greater need for drainage, more alkali is found in the delta than in the basin or flood-irrigated lands south of Cairo.

The absence of black alkali in Iraq was pointed out early in the discussions at Bagdad by Darwish Al Haidari, Director General of Agriculture. His statements were entirely in accord with later first-hand observations made in the central area of Iraq and northward beyond Mosul and southward beyond Basra. Black alkali probably does not exist in lands watered from the Tigris and Euphrates.

By any of the usual criteria of quality of irrigation waters, those of the Nile, Tigris, and Euphrates would be placed among the world's very creditable ones. In fact, the Nile water, at least at flood stage, would be classed as excellent. The concentrations of salts in these rivers, as in most if not all streams, become greater as the rivers recede. Measured in milliequivalents per liter, the concentrations of principal constituents as reported in some of the available analyses of the Nile, Tigris, and Euphrates are shown in Table 1.

TABLE 1

	Ca	Mg	Na	HCO_3-CO_3	SO_4	Cl	Na %
Flood:							
Nile, 4 months	0.64	0.57	0.50	1.44	0.16	0.14	29
Tigris, 3 months	2.41	0.90	0.36	2.76	0.40	0.51	10
Low:							
Nile, 8 months	0.87	0.72	2.04	3.03	0.23	0.46	56
Tigris, October	3.93	1.99	0.44	3.00	1.81	1.55	7
Euphrates, "	3.42	2.84	0.66	2.92	1.79	2.21	10

Each of these waters is relatively low in total salts and each has a "percent sodium" value within the range usually regarded as safe. The use of "percent sodium" ($Na \times 100$/total bases) in the evaluation of irrigation waters has followed as a natural sequence to the development of information on the base-exchange phenomenon and recognition of the adverse effects which absorbed sodium has on soil structure. There has continued to be good agreement that irrigation waters with much more than 60 percent sodium are apt to impair soil permeability; but initially and since then it has been necessary to recognize that in addition to important factors of length and manner of use, a given percentage of sodium in waters does not necessarily have the same effect under all conditions. On the basis of the consideration here given the subject, the major deciding factor in the interpretation of percent sodium would come to rest on proportions of the anions present in the water.

The percentage of sodium in some waters increases very much more rapidly than in others as evaporation and plant use take place: (*a*) If a water contains little HCO_3-CO_3, then with evaporation the concentration of all ions will tend to change in the same general proportions and there

Camels, donkeys, and buffaloes here drink together from the Nile below the dam at Assuit—200 miles upstream from Cairo. From this dam flood waters are diverted out through a canal system over a million acres of Egypt's land.

will be no residual sodium carbonate. The small change in percent sodium will be that resulting from a little loss of $CaCO_3$ and possibly $CaSO_4$. There likewise will be little change in the *p*H of the solution. (*b*) If the water contains much Ca and Mg and a like amount or a little less of HCO_3-CO_3, there will be a large increase in the percent sodium of the solution as the carbonate precipitates out; but, again, there will be no residual sodium carbonate, nor any great change in *p*H. As a third category, (*c*), if the water contains more HCO_3-CO_3 than it does Ca plus Mg, then with evaporation the Ca and Mg carbonates are precipitated and there remains sodium carbonate, and Na is the only important base. Since the strong base, Na, is present with the excess of carbonate, a weak acid, the solution becomes strongly alkaline. It is the presence or absence of this residual sodium carbonate that now appears to furnish a criterion of whether black alkali can or cannot develop in irrigated soils.

There is need for recognizing the foregoing three classes of waters because these waters, in the absence of good drainage or when used too sparingly, give rise in sufficient time to three corresponding kinds of soil, each of which is undesirable: calcium saline soils, sodium saline soils, and alkali soils (either saline or nonsaline).

The waters of the Tigris and Euphrates are in the first-mentioned category: they contain no residual sodium carbonate. Where there has not been sufficient drainage for an adequate use of water, the soils are saline, but calcium predominates. With the provision of drainage, the lands can be easily reclaimed. The Nile water, on the other hand, belongs in the third category. It is low in total salt, but where the drainage, or water use, for the removal of the salt residues from the land has been inadequate, the soils have become saline. During periods of low water the Nile water has a *p*H well above 8.0. The water has such a large proportion of HCO_3-CO_3 that when it is greatly reduced in volume by evaporation it precipitates much of its Ca and Mg as carbonates and silicates, giving rise to an alkaline solution with little else than sodium salts of carbonate, chloride, and sulfate. Such a solution washing onto a soil from neighboring land, or rising from below and moving through it, would bring about the replacement of exchangeable calcium and magnesium, produce a high *p*H, establish impermeability, and, in other words, create those conditions that are descriptive of black-alkali soils. A soil leached until impermeable with Nile water from which the Ca and Mg have been precipitated would not necessarily retain enough of any salt to make it very saline. It is a universal characteristic of black-alkali soils that they yield sodium carbonate when taken up in water. It seems doubtful that black alkali ever appears in initially fertile irrigated land unless the irrigation water contains sodium carbonate or sodium carbonate rises into it from the subsoil.

The mixed conditions of highly fertile soils, saline soils, and alkali soils under the Nile provide ample evidence that the use of an irrigation water that yields sodium carbonate upon evaporation does not always lead to black-alkali formation. Furthermore, soils that contain some black alkali, but which are not yet entirely impervious, can sometimes be reclaimed without the use of soil amendments, by providing drainage and leaching with the water that produced the condition. This has been accomplished in Egypt and also in the United States. In fact, a continuous fluctuation in the degree of alkalinity in black-alkali soils must always be in progress, depending on the amount of leaching that takes place. The loss of soluble organic matter from alkali soils and its return to streams would, upon its oxidation, contribute substantially to the nitrate that is found in some waters such as the Nile. The Nile serves irrigation in the Sudan and also floods great upstream marshlands. These areas undoubtedly contribute both to the loss of calcium and magnesium and to the nitrate of the Nile water.

There are in the United States large irrigated acreages in which black alkali occurs. If it is true, as the observations here outlined indicate, that residual sodium carbonate in an irrigation water is prerequisite and conducive to black-alkali formation, then the composition of waters now in use predicates that there are large areas of irrigated lands that are subject to its formation. Likewise, by

the nature of the irrigation waters in use, there are also large areas that must be regarded as immune. If the possibility of black-alkali formation can be anticipated by recognition of the ionic relations of the water supply, advantage can be taken of the facts, not necessarily as a basis for condemning a water, but rather as a means of establishing the need of precautionary measures. Productivity can be maintained by adequate water use and drainage at less expense than it can be restored by reclamation. By the time reclamation is needed the owners have all too commonly lost both capital and confidence.

Characterizations of the river waters of the irrigated regions of Western United States as regards residual sodium carbonate should be made on the basis of averages of a number of samples or, much better—particularly if flood waters are impounded in reservoirs—on the basis of means weighted for discharge. In a table of analyses of nineteen Western streams of the United States, which were mostly single analyses at single points, five were found by computation to have carried residual sodium carbonate (the Kings, Owens, Payette, Rogue, and Yakima); nine others (the Gila, Salt, Colorado, South Platte, Arkansas, Rio Grande, Pecos, Sevier, and Big Horn) were without it; and five others were marginal to varying degrees.

Among a group of 444 well and stream samples collected in the San Joaquin Valley of California, slightly more than half were found to have carried residual sodium carbonate. As classified by groups, a small but significant positive correlation of 0.19 is found between residual sodium carbonate and percent sodium and a similar negative correlation of 0.20 between residual sodium carbonates and electrical conductivity. Professor R. Earl Storie has kindly compared maps of the San Joaquin Valley marked by the writer to show the occurrence of "black-alkali waters" with his records of the black-alkali soils. He reports: "In general I find nothing conflicting with the alkali conditions shown on our soil maps; in fact, as mentioned previously in this letter, your red dashes check very closely with the black alkali soils of the valley."

Notwithstanding the occurrence of black-alkali and substantial salt accumulations in many Nile lands, that agriculture is one of the most productive in the world. The fifteen or sixteen million people of Egypt are almost entirely dependent for their food and clothing upon the products of about seven million acres of irrigated land.

In Iraq the situation is quite different. Throughout its history, Iraq has no record of the construction of any canal intended to drain or carry away the salt residues from its irrigated lands. Some drainage is due to the proximity of a part of the land to washes, streams, and rivers, but for many centuries the salt applied in irrigation and flood waters has far exceeded the removal. The valleys of Iraq—like Lot's wife—have turned to salt. But, unlike her, the people, until perhaps recently, seem never to have looked back, or around them, or ahead to observe the consequence of their works. If they have, they have failed either to understand or to take advantage. And so it is with much of the valley land along the Euphrates in Syria and its great tributary from the North, the Khabour. After driving over these lands—which seemed to me to abound with geographical and potential agricultural wealth—there remains a mental picture of abandoned canals and villages but great undeveloped resources—or, more strictly—resources waiting to be developed again. My attention was called by a young Los Angeles pilot on one of the Syrian airlines to an abandoned town of good size which we passed over between Hasseche and Aleppo. The eastern outer walls were oval in outline, representing old Syrian, whereas the western section, partially set into the oval, was rectangular, marking it as Roman. The Romans had been there, but, like the other inhabitants, they had given up. All the walls and houses, like the irrigation canals in the country outside the city, have become nothing but slowly melting mud. The water carried by the canals has come and gone, but the residual salt of the water remains behind in the land.

Until the past century, there has probably been little or no intentional drainage in Egypt. But there is a great difference between the physical conditions of Egypt and Iraq. The Nile mud is under-

At Basra, near the Persian Gulf and the Tigris, patties of manure are flattened against the side of grass huts to dry for fuel.

As one goes northward from Homs and into the country drained by the Euphrates in upper Syria, there may be a city or, within a wall, a little group of these strange domed houses of white clay.

Sheep of northern Iraq start on the long trek to Damascus, fattening as they go on spring grass, along a route prescribed by centuries of tribal custom.

At Anshas, in the orchards of the Egyptian King, the hay may be composted to fertilize the oranges, mangoes, and bananas. During the hot, dry summer, 12 acre-feet or more of water will be pumped onto these orchard soils.

lain by gravel beds penetrated by the bed of the river. This gravel provides drainage from the land to the river when the Nile is low. When the river is high, the hydrostatic pressure within the gravel (the land slopes away from the river) sometimes forces water upward through the soil, carrying the salt residues of previous irrigations back into the root zone to injure the crops. Out on the delta the need for improved drainage and salt removal becomes ever more pressing. In the valley lands above Cairo the extension of pumping from the gravel beds to supplement basin irrigation will eventually aggravate an already existent, but now spotted, salt problem.

A complete, or nearly complete, file of analyses of the ground waters of the Nile Valley above Cairo shows an average of about 100 parts per million of chloride —or about 3 milliequivalents per liter. My own computations indicate that chloride content of the ground water of any section of the valley when fully equipped with pumps will increase by an average of about 1 ppm of chloride yearly. This would double the present average concentrations in about one hundred years. When the Nile subsides after each flood there is a substantial return movement of water from the gravel to the river. This return movement is helped by the sheet of flood water that is spread over the country. On the average about 40 percent of this flood water is

thought to return to the stream—either as surface runoff or as deep percolation. With this return there is a substantial (but never complete) return of the annual salt residues. If this annual return of salt had in the past been complete, the well waters would resemble river waters, but many wells are now too saline for use, and furthermore salt appears on the surface of the land along the valley margins. Annual pumping will lower the water in the gravels, and the next rise of the river will replace the water that has been used by pushing the residual water of the gravels out laterally from the river toward the valley margins. This lateral movement of water will, of course, carry with it the salt residues that have been leached downward from the overlying soil. The fact that pumping reduces the volume of gravel-stored water will increase the amount of new water that enters with the flood. The last water to enter the gravel from the river as it rises is, after probably only a little mixing, the first to leave as the river falls. Since the river water entering the gravel has only a little salt, the wells closest to the river may tend to improve, but to a greater extent the wells further away will become worse.

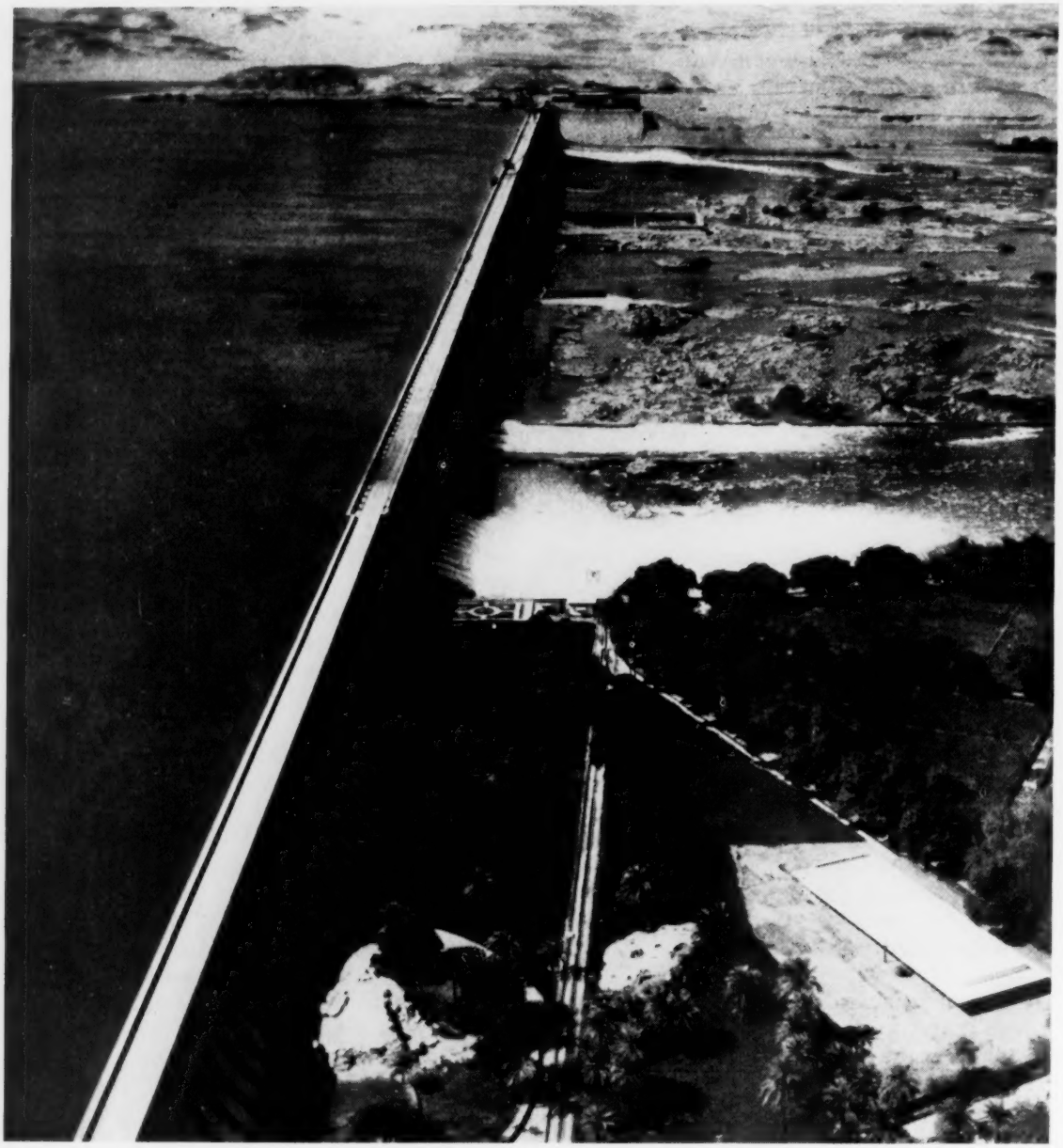
Under these conditions the accumulation of salt in the gravels and overlying soil will necessitate a great expenditure for drainage ditches along the margins of the valley to the sea—a distance of 550 miles from Aswan to the Mediterranean. Egypt, like Iraq and the United States, has been more intent in the past upon planting and watering a new crop than in saving one or making those a few years ahead more worth while.

As has been implied, one may travel for miles through the valley lands of Iraq almost continuously observing the remnants of abandoned irrigation works. Nearly everywhere there is salt—if it is not lying white on the surface of the land, the soil itself is usually impregnated. Southward from Bagdad and westward from the Tower of Babylon there are the remnants of a great canal, once served from the Euphrates, which measures eighty feet across its floor. Other great canals that once diverted water from the Tigris or its tributaries are found northward from Bagdad toward ancient Nineveh. These once served beautifully lying lands that are now salt-impregnated. Also to the north there stands a partially washed-out masonry dam on Shatt Al Adhaim. Both the canals and this dam were in use more than 2,000 years ago.

The irrigated agriculture of Iraq is at a low ebb, but there is an abundance of water, and the climate is well suited to dates, cereals, cotton, and many other crops. The date palm is especially salt-tolerant, and it has come to be of great importance to the economy of Iraq. Where the natural drainage is good, excellent crops may be produced, but such locations are now limited. An irrigated grain crop is produced each second year on some of the valley lands. The intervening year permits of a little fall in the ground water and with it perhaps a little drainage of salt and, further, a fixation and accumulation of a little nitrogen. (Commercial fertilizers are practically unknown in Iraq.) Where they can be grown, the oranges and mandarins of Iraq are excellent and free from scale insects. On the naturally drained lands—as along washes and rivers—the dates are twice as productive as on the highly saline soils. Palms come into bearing in seven years where they can be watered from the surface with fresh water, whereas fifteen years are required when subirrigated with water backed up with the rise and fall of the tide. On the way back from Basra I looked out of the train window about three o'clock on a moonlit morning. I first thought that it had been snowing, and yet I knew it was too warm. The countryside was covered with white salt, and save for a few scattered palms there was no vegetation.

Iraq is said to have had at one time a population of forty million people, but at present there are less than five million. Many of these are Bedouins and others who derive their living from the unirrigated hill lands in the northern part of the country. From these hills droves of sheep are driven yearly toward Damascus or the Mediterranean, feeding and fattening en route on the grass that covers the land in the spring. Opinions differ as to when and why this supposed much larger population of Iraq disappeared. One interpretation of the disappearance is that the people were killed during the Mongolian invasion of the twelfth century. Possibly so, but, as I view it, it is most improbable that these lands with the salt they now carry could support many more people than they are at present supporting. Until proved otherwise, it is logical to believe that Iraq provides a striking example of the decline of a great civilization—all because of a little salt in the water and the want of a few ditches. Compared to the magnitude of this slow-moving event, our dust bowl was but a passing incident.

Iraq has the heritage of tremendous oil reserves and two great rivers. For the waters of these rivers there are waiting an estimated fourteen million acres of arable land; but also waiting is an excess of about one billion tons of salt, which must be transported through drainage canals to the Persian



Life begins at Aswan. Here for the first time in Egypt, the Nile encounters a great barrage that checks its flow. Electrification of this gigantic dam is now taking place, and it will shortly provide 354,000 horsepower, for the benefit of all Egypt.

Gulf. Who can say how soon those who administer this potential wealth will decide to invest oil royalties in drainage canals and new irrigation works? Should such a start be made on a sizable scale, the result should be like the course of a snowball from the top of a hill. With adequate support, the Iraqian agriculturalists and engineers could within the span of a few decades literally create a new Garden of Eden. And, of perhaps greatest importance, these agricultural gains could conceivably proceed rapidly enough to outstrip the population gains. Throughout much of the world, agricultural improvements have little or no opportunity to move much if any faster than the increase in the number of people. Actually, hungry mouths are already waiting upon the agricultural gains. Under such circumstances, the people as individuals remain just as poor as ever. But in Iraq, as in northern Syria, there could be developed communities of people with sufficient wealth and income for education, social enjoyment, and security far beyond those of their neighbors.

MAN AND HIS PREJUDICES

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MUCH has been written about the threat of prejudice in undermining our democratic institutions. Specific instances can be cited in regard to the growth and magnitude of man's antipathy to man. It seems worth while, therefore, to analyze carefully the fundamental nature of these antipathies in order more sanely to comprehend these savage undercurrents in our daily lives and so attack the problem at its most vulnerable point.

The universality of men's aversion for one another is shocking in its implications. Negativism, once a problem relegated to the confines of early childhood, has become the order of the day among the adults of every nation. Group is pitted against group: the Protestant attacks the Catholic, the Catholic attacks the Jew, the Jew mistrusts the Gentile, the white persecutes the Negro, the Negro turns on his white enemy. Whatever the manifestation of these antagonisms—whether it be racial, ethnic, religious, or class—a common thread runs through the entire web of intergroup relations.

There are many general types of prejudices, but two loom largest on the horizon, dwarfing all others. The first of these is easily recognizable. It is the kind that expresses itself in overt forms of group opposition. It is the type of prejudice that keeps certain groups from living in designated areas of a city, bars them from schools, deprives them of voting privileges, and excludes them from hotels, clubs, theaters, and so on.

This sort of prejudice is vicious from the standpoint of democratic principles, but it is in a relative sense capable of being handled, since it expresses itself in tangible forms—usually in terms of ordinances and statutes. Given enough people who desire a change, the laws can be repealed. It would appear that there is an ever-growing number of people who are sincerely interested in effecting such a change.

Even if this overt form of prejudice does not express itself in law but in the form of a "gentlemen's agreement" to keep members of various minority groups from obtaining their rights of citizenship—in gaining admittance to hotels, schools, and stores—it is still concrete enough to allow for direct treatment. It involves specific persons who are *principally* responsible for this form of discrimination, and these, skillfully approached through influential community leaders who are truly desirous of mitigating the problem, can be made to modify their rulings.

Thus, by group action to change the law, or through the pressure of public opinion, some of these discriminatory practices may be obviated.

There is another type of prejudice, however, which is more basic and more insidious, difficult to rout from its hidden recesses, and almost impervious to any form of concrete action. It is subtle, covert, and noninstitutionalized. An illustration will serve to indicate the nature of this form of prejudice.

> I once boarded a city bus and chanced to sit next to two women, residents of a southern city. One lady was telling the other that she had just visited Mrs. R—— at the hospital.
>
> The other lady said, "Oh yes, I know who she is. She is your neighbor, isn't she?" "Yes," was the reply. "And she is a Catholic, isn't she?" "Yes," was the reply again. "And on the other side of you lives Mrs. S——, doesn't she? And I think she is a Catholic, too?"
>
> "Yes, she is," the first lady replied. And then, with a sigh of resignation and suffering, she revealed her attitude by adding, "and you know what it feels like to be hemmed in by two Catholics."

No objective listener could deny that here at least was one prejudiced individual. It is true that this type of prejudice is unlike the first. The "hemmed-in" woman would probably not attempt to have instituted laws, ordinances, or even agreements that would keep her Catholic neighbor from visiting any hospital she might please. Their children probably play with one another; they may attend the same school. And one would not imagine that she would be ready to institute, or formally banish, the Catholic children from the neighborhood or theaters.

The revealed prejudice had not reached the form of outright discrimination, true. But prejudice was there. It was not formalized, but rather

it existed as a kind of folkway prejudice, a kind of "general feeling of againstness." It reflects the general folk atmosphere.

Although it is unlike the first type, sometimes, if not quite frequently, it may lead into the first type, given an economic or political crisis, when the general negativism might easily turn to outright discrimination, scapegoating, or persecution.

Nazi Germany has given us our best case in point. In the days of the Weimar Republic the Jews enjoyed legal freedom and political tolerance. Laws forbade educational, economic, and legal discrimination. Legal guarantees, however, were not safeguards against folk feeling. A preponderance of evidence exists to prove that many Germans continued to feel differently toward the Jew than they did toward the non-Jew. When a crisis situation arose and a skillful demagogue appeared on the scene who played on this submerged feeling of againstness, organized scapegoating and massacre were easily achieved. In other words, this type of folkway prejudice, which ordinarily appears merely silly, rude, unfair, unkind, or antidemocratic, holds within it a submerged threat for the future as well as unpleasantness—or worse—for the present.

Interestingly enough, it is the nature of folkway prejudice to be almost universal. Members of primitive tribes manifest a general feeling of againstness toward the "outsiders," those who are not members of their own group. The Caribs believe that they "alone are people." The Lapps call themselves "human beings," implying that non-Lapps are not. Literally translated, Kiowa is "real, or principal, people." The Greenland Eskimo believes that Europeans have been sent to Greenland to learn virtue and good manners from him. The highest form of praise that the Eskimo can extend to a European is that he is, or soon will be, as good as a Greenlander.

This feeling of superiority that people feel toward their own way of life and their own group is not limited to the primitives. The ancient Greeks referred to the non-Greeks as barbarians. It is of course true that the Greek word *barbaros* did not have the identical meaning that our own word "barbarian" has, but it definitely attributed strangeness, rudeness, and inferiority to the non-Greeks.

Nor is this feeling of superiority, or "ethnocentrism," the term coined by Graham Sumner, limited to ancient peoples. To the query "Who was the first man?" a youthful patriot answered "Washington." "No," said the teacher, "the first man was Adam." "Oh, I suppose he was," conceded this small isolationist, "if you are going to include foreigners." Among Western "civilized" peoples we hear the constant use of such terms as "chocolate drop," "du-donk," "nigger," "Dutchy," "flip," "greaser," "dogs," "wop," "kike," "coon," "chee-chee," and others too distasteful to record.

Commenting on the story of Jesus, the Jew, told to a Sunday-School class of ten-year-olds, a pupil declared that she had never known that Jesus was a Jew. After further elucidation by the teacher, this youngster declared that she had always known "that God was a Presbyterian, but not that Jesus was a Jew."

Thus it goes, from one end of the world to the other, even filtering down to the jingles of children at play. A Dutch nursery rhyme tells us that:

> The children in Holland take pleasure in making
> What the children in England take pleasure in breaking.

This strongly rooted attachment to one's own way of life and one's own people has been observed through the ages by poet and scientist, the widely traveled diplomat and the secluded scholar. As Oliver Wendell Holmes so aptly remarked, "The people in every town feel that the axis of the earth passes through its Main Street."

I

It is this very group consciousness, or ethnocentrism, which lays the foundation of group prejudice. If there were no strong feeling for one's own group, there would not be strong consciousness of other groups. An awareness of one's own group as an in-group and of the others as out-groups is fundamental in group relationships. Group tensions are manifested by a sense of distrust or dislike, not to an individual as such, but to an individual as a symbol of an out-group. It does not always follow that a consciousness of one's own group leads to distrust and disharmony with all other groups. The friendly rivalry that exists between athletic teams, or the competition between rival garden clubs, for instance, points to the fact that not all group relations give rise to group tensions.

There appears to be present in all types of group prejudice some degree, whether real or imagined, of struggle or threat. So much of group prejudice, however, is linked up with imagined threat rather than real that a challenge is offered in attempting to understand it. The very universality of group antagonism has led many laymen to accept the inherent, innate, organic nature of these prejudices. So strong was this belief that up to thirty-five years ago it was a valid fact to the psychologists. Psychologically speaking, it was regarded as but one more instinct, along with mother love, pug-

nacity, curiosity, gregariousness, self-preservation, and fear, to name but a few.

The doctrine of the instinctivists has been pretty well discarded in the light of further and keener psychological research. No longer can the student of human nature accept the thesis that any human attitudes are inborn. No aspect of man's human social nature is inborn. His wishes, his beliefs, his knowledge, and his values all come as a result of his association with other men. They are developmental, not congenital. Attitudes are nurtured, not natured. Prejudice is fostered, not fathered.

We inherit biological traits such as the shape of the skull, the color of eyes and hair, the potentialities of tallness, all of which are carried through the germ plasm. Prejudices—indeed all our attitudes, habits, and emotions—are not carried in the germ plasm. They are developed by the culture that surrounds us: in early years, chiefly through the family groups; in later years, through other institutions—the church, the school, business.

The first few years are the most impressionable ones of our lives. The young child learns primarily from his parents. Children repeat what they find about them rather than invent their own forms of behavior. Thus the child acquires early in life those collective, specific attitudes of prejudice that exist in the family. These tend to remain with him and are often deep-rooted and unconscious.

When these prejudices in the family become further re-enforced by the community, society in general, and later associates, it is easy to see how ingrained and well established one's prejudices can become. And the tendency for prejudices to persist thus becomes comprehensible. For those with prejudices give them to those without them and, once acquired, they become further indelibly stamped. It becomes apparent, too, why it is that for generation after generation prejudices toward certain groups and persons are perpetuated.

This tendency toward perpetuation of group prejudices becomes understandable if we are aware that it is the nature of these prejudices, as well as of most attitudes, to be emotionally loaded. Prejudice consists of a pre-existing emotional tendency to act negatively toward a particular group, idea, or value. The very nature of prejudice presupposes feelings about things. Usually this emotional core is primary in these prejudice tendencies. Often reason supplies the rationalizations for existing prejudices. Emotions lead; reason apologizes and defends the prejudice.

Because attitudes of prejudice are full of emotion, it becomes clear not only why they persist, but also why it is difficult to be emancipated from them. Many instances exist that show how difficult it is to overcome prejudices, even though one is aware of the lack of basis in fact for his prejudice. For example, an intelligent and educated woman in the late fifties, who was born in the South, told the writer that although she was aware that the antiquated notions about the innate inferiority of the Negro are false rationalizations—that shape of nose, texture of hair, and pigmentation of the skin have nothing to do with mental ability, human morals, and interpersonal etiquette—she just could not help herself. By this she meant that given the stimulus, "Negro," she gets an emotional negative reaction, which is not reasonable or planned but nevertheless manifested and real. Her prejudice toward the Negro is an emotionalized phenomenon which appears automatically as a result of the previously established attitude toward the Negro. Usually the attitude is developed quite early in life. It often persists in spite of enlightenment and knowledge. People may "know better" but still are prejudiced.

Before we suggest what can be done about these emotionalized prejudices toward specific groups, a further word must be said about another type of attitude that man is capable of developing. We have spoken about specific prejudices, specific attitudes— attitudes toward Negroes, the next-door neighbor, the child on the other side of the tracks. These are specific attitudes directed toward specific objects. But there is another set of attitudes that tends to govern man's behavior and often determines the type of specific attitudes he will develop. A person has an attitude toward a particular individual, and he also has an attitude toward people in general. Besides having an attitude toward a particular member of the opposite sex, one has an attitude toward members of the opposite sex as a group, or toward sex in general.

Sometimes one's attitude toward a particular individual may be the same as the more generalized one. Very often it is not. One may be sincerely fond of, and favorably disposed toward, a particular Negro and still possess race prejudice and be anti-Negro. A person may be in love with a particular member of the opposite sex, but may have prejudicial attitudes toward members of the opposite sex as a group. He may elevate the particular member on a pedestal of social superiority, act obsequiously to her, sincerely feel inferior. Still, if he be an employer, he may be prone not to hire women. He could think and believe that a woman's place is in the home, that this is, and should be, "a man's world."

We can generalize these attitudes even further. Besides having a certain attitude toward a par-

ticular individual or a group, one also develops attitudes toward people in general; or even toward life in general. What do we mean when we say a person is not sociable? Or that he is an introvert? Or a cynic? We do not mean that he portrays an attitude toward a particular individual or group, but that he has a *general* tendency to act in a particular way toward all people and all groups. A cynic is not one who distrusts an individual as much as one who distrusts all people. The same holds true for an introvert. He is not so much one who "turns inwardly" in particular situations as he is one who practices introversion in most of life's situations. A "prejudiced individual" is one who is generally prejudiced. He may manifest his prejudices toward particulars only; on the other hand, one who is generally prejudiced will act in a prejudiced manner in many of, if not in all, life's social situations.

General attitudes therefore exist and are real, too. How else are we to understand the frequency with which prejudices often come in clusters? An individual who is *anti* a particular group is also anti-group B, C, D, and so on. We find that a tolerant person is not one who limits his tolerance to particulars. Rather, his tolerance usually pervades most of his relationships and experiences. General attitudes are chronic attitudes. The more numerous the situations that arouse a particular mode of behavior, the more general and basic the attitude behind the behavior. One who dislikes Negroes, Jews, Catholics, and children has a tendency to dislike people in general. One who dislikes people is a hostile being. And a hostile person possesses a basic general predisposition of prejudice. How his hostility will express itself depends on the definitions of his society and group. If a community is anti-Catholic, this hostile person will be prejudiced (overtly) toward the Catholic. If the community is anti-Negro, a basic attitude of hostility will arraign him against the Negro. People are what their dominant basic general attitudes are, and people do what the community dictates.

II

Specific attitudes are formed all through life, but basic general attitudes develop quite early in life and are mainly motivated by the family and other primary intimate face-to-face groups, such as the child's play group and the neighborhood. Unlike the specific attitudes, they are less capable of change and alteration, once formed. As long as an attitude is localized, it is capable of change, given a new experience. A person may change his attitude toward a particular individual when he "finds out more about him." A hostile person is not hostile because of a particular experience, but rather because of the fusion of many experiences in early life, until his tendency toward hostility becomes dominant. He has a general tendency to interpret all situations in a hostile manner, and his basic general attitude is not limited to particular objects.

Here again we are faced with an extremely difficult problem if we desire to effect a change, primarily because these attitudes are quite fully developed during the first years of life and, second, because they, too, are emotionally charged. In what other wise can we understand the high incidence of recidivism among criminals and juvenile delinquents? Although antisocial criminal behavior is not inborn, unless powerful reformistic programs are undertaken in our corrective institutions—and even then—one with a criminal bent tends to remain that way. It has often been shown that juvenile experts have ceased trying to alter the basic general attitudes of the bully. Once this aggression-domination tendency develops in an individual, it appears exceedingly difficult to reduce its degree. Without question, it appears even more dubious that a dominating, aggressive individual can ever change fundamentally into a nonaggressive, submissive type. In fact, juvenile experts do not seek basic attitudinal changes. Rather, they seek to constitutionalize the bully. Instead of allowing his bullying to express itself in the unsupervised street-corner gangs, the juvenile gang leader is made president of a club, or the captain of a baseball team. His aggressive tendencies still prevail, but now they are channelized into more acceptable social behavior.

If society could find a way of channelizing the hostile prejudicial tendencies of some people by furnishing outlets for their basic attitudinal drives, we might avoid the group tensions and group antagonisms that have not, of course, a place in democratic societies. If the bigot could be given the opportunity to fulminate his hatred against war, poverty, and disease—against objects of societal disapproval—the villain might even become a hero in the eyes of society. This is a task for education. Education of construction, that is—not education to reform the basic personality, but to open areas and outlets of satisfaction for already developed basic attitudes.

A more important task for education, of course—and specifically for the family as an educational unit—consists in integrating and normalizing the personality while it is being formed, in supplying the child with primary attitudes of tolerance rather than prejudice, with security, sympathy, and the

other human virtues of love, pity, concern, and sociability. This task for the family is the greatest challenge. It is easier to form attitudes *ab origine* than to change them *post maturus*. Baldur von Schirach, the leader of the Hitler youth movement, made an interesting and significant comment when he told an Army psychiatrist at the Nuremberg prison that he believed German children under ten could be directed toward democracy as they were toward Nazism, but that those older than twelve could be considered absolutely lost to democracy. He believed that just as Hitler "pulled young people away from their non-Nazi parents, so American authorities must remove today's children from their Nazi-poisoned parents."

Nazism was a general way of life in addition to the specific modes of reaction to particular objects. Nazis possessed basic general traits of social hostility to the outside world, group conceit (extreme ethnocentrism), personal and group aggressiveness, personal and group paranoia, group militance, and a tendency to blame others for their own and the world's ills.

Where do these general tendencies arise so early in life if not in the family? Studies of the development of basic general attitudes suggest that they are not a consequence of immanent mental development, but have their origin in the parents. Toward adolescence, children lose awareness of these origins and often devise rationalizations to support them. A young child, finding that his mother is not on speaking terms with her neighbor, refrains from associating with the neighbor's children. He will often accuse them with words repetitive of his mother's condemnatory remarks. And so he will take over his mother's attitudes toward other people and objects. If the mother portrays a general hostile attitude toward the outside world, her overt acts and expressions gradually fuse in the mind of the child until the imitation of his mother's specific negative habits of behavior becomes a general tendency to behave in a hostile manner. The many acts have become a basic predisposition which is fundamentally the same as the mother's predisposition. As the child matures, this basic dominant trait will force and compel specific behavior in specific situations. In extreme cases he will even offend those particular individuals he sincerely loves. A general tendency to behave colors the specific act itself. Man does not evaluate every stimulus that confronts him; rather, the stimulus becomes for him what he makes of it. And he makes of it what his dominant basic attitudes are. "Children," says George Brock Chisholm, Director General of the World Health Organization, "must be taught to live harmoniously together or mankind will follow the dinosaur into oblivion."

In order for children to develop the "correct" attitudes parents must be made aware of their inherent prejudices. How can this be done? Some self-analysis becomes necessary. It should be pointed out to adults—and here the task for adult education becomes most significant—that persons coming from particular strata and segments in society tend to possess the interests and biases characteristic of that segment. Only the few are the exceptions. A white, urban, Protestant, wealthy, middled-aged, Northern male will not possess the same tendencies to act toward given values, groups, individuals—will not have the same interests, attitudes, and predispositions—as a colored, rural, Catholic, young, poor, Southern tenant farmer. Can these two possibly feel the same toward the question of social security, toward equal educational opportunity for all groups, toward taxation, and an endless variety of other social issues? Residence in particular segments of society bring pre-existent reaction patterns.

White persons must be on their guard to avoid slips of the tongue about Negros—especially in front of children. Protestants can exert special effort in not expressing or showing through divers manners their dislikes of Catholics or Jews—again, especially in the presence of their children. On the other hand, the adults comprising minority groups can minimize their feelings and attitudes of insecurity, withdrawal, resignation, and unnatural aggression by becoming aware of these tendencies.

Only in this way can we break into the perpetual cycle of those who have prejudices passing them on to those who have not, thus making an endless chain of hatred and antagonism among men. Adults can and should be made conscious of their predispositions so that their children need not duplicate their parents in this regard. If the adult avoids specific acts and expressions of prejudice, no groups will consequently become defined in the mind of the child as objects of antagonism. If no groups are thus ill-defined, the child will obtain nothing to integrate into a *general* attitude of prejudice.

People often ask whether there are not any *good prejudices*, such as prejudices against war, crime, and poverty. Prejudice means prejudgment. If one's beliefs and ideas result from prejudgments it is difficult to see that an attitude for or against any object, group, or value can be condoned. Absence of reason is a poor excuse for any judgment, even if it happens to further the good society. The good society can be and should be reasonable. It surely cannot succeed through capriciousness.

THE WILLOWS: HELPERS OF MAN

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WILLOWS are native to all continents except Australia. Although they are nearly world-wide in distribution, most of the 500–700 species are found in the Northern Hemisphere. About 20 kinds occur in temperate Africa and one in South America.

Three recognizable but overlapping east-west belts of willows occur in the Northern Hemisphere. The relatively few tree willows of the warm-temperate and subtropical belt extend from the Philippines across southern Asia, the Mediterranean region, and southern North America. They are typified by our eastern black willow (*Salix nigra*) and western red willow (*S. laevigata*). The cool-temperate belt of some hundreds of shrubby willows extends across the central part of the three continents; these willows are typified by our Bebb willow (*S. Bebbiana*) throughout; sandbar willow (*S. interior*), central; and cordate willow (*S. cordate* Muhl.), eastern. The arctic belt of some 100 kinds of little prostate willows extends into the Arctic Ocean, and southward on mountain ranges into the United States. The circumpolar arctic willow (*S. arctica*) and net-veined willow (*S. recticulata*) are typical.

In relation to sea level, willows range from 200 feet below in California to 15,000 feet above on various mountains. Two of our species, the sandbar willow and the western shining willow (*S. lasiandra*), range from about latitude 30° (Louisiana and Mexico, respectively) to 67° on the Yukon River in Alaska, and withstand temperatures of 100°–130° above zero F. in the South to about 75° below zero in the North. Willows in general prefer moist to wet situations, but our dry-land and desert willows withstand long periods of drought.

The tree willows vary in height from 15 to 120 feet, with one to four trunks. Shrubs vary from a few inches to 15 or 20 feet in height, with few to scores of stems. The prostrate willows rise in height from a fraction of an inch to 1 or 2 inches, and form mats from 2 inches to 1 or 2 feet across.

Willows are widely used for cover, shelter, homes, and/or food by many kinds of animals, birds, insects, and even fishes. These associations supply many common names, such as willow ptarmigan and warbler, willow moth and sawfly, and even willow catfish. Many plants, having narrow leaves like the traditional willow leaf, are named from this resemblance (willow herb, willow oak, and desert willow). This traditional idea of the shape of willow leaves ("willowy") arose from the long slender leaves of the tree willows of the ancient world. In fact, however, the leaves of willows vary from literal toothpicks through linear, oblong, lanceolate, and oblanceolate to oval, ovate, obovate, suborbicular, and completely circular in shape, or even circular with both ends indented.

Willows produce enormous numbers of tiny parachuting seeds, which reproduce sparingly and die soon. Much reproduction is by twigs blown or broken off and washed or tramped into mud, sand, or gravel. They spread also by underground stems and roots, which may run out for 5–75 feet, sending up shoots as they go. Willows can produce buds or roots from any part of the stem or root.

The willows, genus *Salix,* with the closely related poplars (aspens, cottonwoods), genus *Populus,* comprise the willow family—Salicaceae. In English, the willows are called willows or sallows, and the basketmaking sorts often are called osiers. The word "sallow" occurs in all medieval languages. The name "willow" (*welogh, wyllo*) is derived from the Anglo-Saxon *welig, wilg,* etc. and the Low German *wilge* and *wichel* ("wicker").

USES OF WILLOWS

Willows have been useful to man, directly and through his animal friends, in a thousand and one different ways since before the dawn of history. These uses enter into every phase of his existence, material, physical, and mental, in activity and in relaxation. Willows have supplied man in all

stages of his development, from most primitive to most "civilized." Just a bare list of the things made or done with willows forms an amazing tableau of the upward climb of the human race.

Sentiment and superstition. Willows have entered into the ceremonial and religious rites of many primitive peoples (including Aryans). Of the six references to willows in our Old Testament Scriptures, four make them the symbols of fertility, vigor, and rejoicing; only one associates them with mourning (Psalms 137: 1–2, Children of Israel Captive in Babylon). From then on, our popular association of willows with mourning has been dominant.

Willows were important among the *arbores tristes* ("trees of sorrow, or mourning"), used in burial places from time immemorial, and our present use of the weeping willow in cemeteries is a custom survival. In twelve of Shakespeare's plays, the willow is the emblem of mourning, sorrow, and tragedy; in *Hamlet,* Ophelia drops to her death from a willow. Throughout medieval times, songs of sorrow were widely popular, and in many of them the willow was the symbol of grief, desertion, and despair. Garlands of willow were worn by forsaken lovers.

Superstitious beliefs about willows are many. In parts of Europe, it is believed that geese hatch from pussy willows; also that rheumatism will be cured if the victim walks thrice around a weeping willow as the sun sets. In the superstitions of the ancient and modern herbalists, willows were ascribed almost miraculous powers over disease, especially of the sexual organs. Man still uses withes as divining rods.

Art and ornament. Willows long have been subjects for paintings in Europe, especially those of Corot, and there are beautiful Chinese examples. Photographs, books, magazines, and photogravure supplements frequently portray them. The Oriental willow pattern in chinaware has been introduced around the world in past centuries and recently has been transferred to wallpapers.

The use of willows in ornamental plantings is universal. Some trees, like the white willow, are grown for the beauty of the silvery-silky leaves; others, like the weeping willow, for their pendulous, swaying branchlets. Many shrubby kinds are grown for their leaf effects in summer and the bright reds and yellows of the buds and twigs in winter. Pussy willows are widely used for the beauty of the furry yellow male catkins on leafless stems in early spring. Two European species, florist's willows, decorate our homes and churches at Eastertime.

Making of wooden products. Willow wood is used for many and varied products. Light in weight and usually light in color (caused by low mineral content), it does not warp, check, crack, or splinter if properly seasoned. These qualities give it high value for many purposes. The four chief classes of material used are timber (trunks and poles), lumber, withes (slender rods), and roots.

Willows long have been cultivated commercially abroad. In America, they are seldom used for wood products, except withes for basketry and wickerware. Timber and lumber here normally come from wild plants or those grown for windbreaks, soil-holding, or ornament. Native black-willow timber is cut largely along the lower Mississippi.

The making of containers for picking, carrying, weighing, storage, and shipment of various products is an enormous industry. It is ancient and modern, primitive and civilized, household and commercial. Willows are preferred because they are light, easily worked, and durable. Withes and roots and sawed lumber are used in four different types of construction: withes or roots woven; narrow strips of thin lumber woven or plaited into baskets or crates; the same nailed to heavier braces or ends for boxes and crates; and all cooperage (barrels, etc.).

Use of peeled willow withes, and roots, in making baskets, hampers, and panniers is very ancient, having been widely established in Greek and Roman times. Today, baskets, hampers, and crates are universally used for picking, carrying, measuring, weighing, storing, and/or shipping grains, seeds, vegetables, fruits, berries, melons, nuts, flowers, groceries, butter, eggs, cured meats, fish, bakery products, fertilizers, ammunition, lime, earth, sand, gravel, kindling, fireplace wood, laundry work, yarn, thread, buttons, sewing materials, and also cages and coops for birds, animals, and poultry. Many Indian tribes are experts in the making of beautiful baskets of withes, split withes, and roots.

The plaited and reinforced containers are used for many of these same purposes, especially in shipping. Cooperage includes barrels, half-barrels, casks, kegs, tubs, etc. Tight cooperage is used for liquids, products packed in liquids, and fine materials like sugar, salt, sulphur, etc. Slack cooperage may be used for firm fruits, cranberries, vegetables, and nuts.

The principal, long-time uses of willow wood in agriculture have been for fences, orchard props, vineyard trellises, tying materials, tool handles, and tools.

In Europe, willow poles and rods are used extensively as wattles or fillers in open fences, and

FIG. 1. Crack Willows, Du Pont Powder Mills, Wilmington, Delaware, pollarded (trunk cut off several feet up) and each producing scores of slender canes for charcoal used in gunpowder manufacture. (Photo by U. S. Forest Service.)

also in constructing movable sheep fences, called hurdles. In the drier, unforested parts of America they have been much used for fence posts. Such fences often carry the rural telephone lines, and willow poles carry the line to the farmhouses. Early-day rail fences were interwoven with willow poles to restrain hogs and sheep, and later the few-wired slack barbed-wire fences were reinforced with willow poles or rods for the same reason.

Willow poles, props, and trellises have been used in gardens, orchards, and vineyards from ancient times. (The Romans wrote extensively on growing and using willows in their agriculture and horticulture.) All over America, they still are so used. California orchardists suffered loss when a willow weevil moved from the props to the trees and became a serious pest. Willow poles long have been used for home making of handles for hoes, rakes, brooms, shovels, etc. This use, once common in America, still goes on in Eurasia. In China, three-tined pitchforks are made from properly branched stems dried under pressure.

English beehives ("bee slips") still are made of willow. Willow wood often forms the blades, and sometimes the frames, of water wheels, because it is uninjured by water. Fans for winnowing grain were made from willow by the Romans, and probably wicker sieves also. Slender willow withes as tying material date back to antiquity and still are used by modern florists, gardeners, and vineyardists.

Willows furnish fuel in many unforested regions to explorers, travelers, and dwellers, the latter using both wild and planted. One brick manufacturer in Missouri fires his kilns with willow. Arctic willows furnish fire for outdoor summer cooking. Some Indians use willow for smoking fish, claiming that no taint is absorbed. Eskimos twist beaten cottony materials (willow seed hairs, moss, etc.) into wicks for oil lamps, and Siberian natives make candles of willow twigs shredded by stone beating, then braided together and soaked in blubber oil.

Wicker furniture, from woven willow withes, is of ancient origin. It now includes armchairs, rocking chairs, settees, tables, cribs, baby and doll carriages, perambulators, etc. Dressed willow poles usually form the legs, braces, and frames. Rustic furniture is made of willow poles, debarked or with bark, and includes chairs, benches, and settees. These are not smoothed, polished, or painted and are used mostly out of doors. Willow lumber does not take a high polish and is used generally for interiors in cabinetwork, such as drawers and shelves for bookcases, bureaus, cabinets, closets, desks, tables, and also in pianos and refrigerators.

Willow is widely used for some household

utensils because it is light, free from warping and cracking, and resistant to heat and water. Among kitchen and store utensils are bowls, ladles, scoops, spoons, and trays. Other articles include lap-, sleeve-, and ironing boards, and cutting boards and tables for leather workers. It is a favorite carving wood and is used in teaching that art. Siberian natives use leafy willow twigs for covering tent floors, and Amerinds make floor mats from willow twine. Willow twigs beaten and shredded at one end are used by Mohammedans and some primitive peoples in religious and ceremonial rites; these shredded twigs are probably the prototype of toothbrushes. Our Southern mountaineers used similar twigs as snuff sticks.

Willows provide important equipment for man when he walks, or rides on animals or in vehicles, or travels by water. Indian tribes make sandals from willow twine, and, in the Low Countries of Europe, all the widely worn wooden shoes are made from willow, because the wood is light and not warped by wetting. Canadian Indians use willow for snowshoe and hand-sledge braces. Aids to walking include wooden legs, crutches, and canes. Wooden legs have been made from willow since shaping them began in London some 125 years ago. Our "diamond-willow" canes are much prized as novelties.

The frames of Greek and Roman coracles (small, tub-shaped skin boats) were willow, and probably their oars or paddles also. Recent European coracles still are willow-framed. Eskimo kayaks, or skin canoes, have willow frames and spreaders. Small boats, and oars and paddles, still are made from willow by white men, as are also the keels for larger boats. River steamers usually burn bank-cut cordwood, and in Mark Twain's day some of this was willow—and perhaps it still is today.

For land travel and transport, by horse and vehicle, willows long have been useful. Perhaps the earliest transport of supplies (and children) was in woven willow panniers, balanced one on either side of an animal. When the Spanish ruled California, the "trees" of their famous and widely exported saddles were of willow. The *travois* poles of the Indians, French guides, and trappers were willow, the forward ends attached on either side of a pack pony, the rear dragging, with a load lashed to crossbars behind. The country boy astride Old Dobbin carried a willow switch for service and sentiment. Wicker baby carriages and perambulators transport our young. Willow is used to line carts, wagons, and wheelbarrows in Europe and also to line the brakes of wagons and tram- and railway cars.

In fishing and hunting equipment, the farmer boy and his willow fishing pole are well known. Sioux Indians snare the long-bodied pickerel with a running noose on a willow pole, and Northern Indians seine fish with willow-twine nets. Conical fish weirs, or traps of willow withes, are set in narrow channels to catch fish. Northern Indians attach rabbit snares to bent-over willows, and use willow-handled ice bags and strainers when fishing through ice. Willow withes tie the rails of the trap corrals and the poles of the caribou lookouts of Alaska-Yukon natives. Bear Lake Indians use a willow whistle to call loons, and they call moose by rubbing the shoulder-blade of a moose against willow stems, thus imitating the noise made when the animal rubs the velvet from his antlers in the spring.

Baseball and cricket bats, polo balls, fishing poles, doll carriages, snow-trail markers, whistles, rattles, and various toys are also made from willow, and willow bats and fishpoles are universal in juvenile America. All the cricket bats, standard and junior, of the British people are made from white willow. Withes mark trails accross blowing snowfields for mountain climbers. White and Indian children alike make willow whistles, and the latter also make willow rattles containing stones.

Both ancients and moderns have used weapons of willow. The rawhide-covered shields of the Roman legions were woven from four kinds of willow. Slave Lake Indians use long shields of willow withes as defense against arrows. German willow holts in World War I were overcut to supply ammunition crates. Willow charcoal was universally used to make gunpowder. Many Indian bows, and sometimes arrows also, were made of willow.

Excelsior, shredded wood, and wood-pulp are the basis for a large modern industry, of which willows probably furnish only a small part. Excelsior mills have used some willow from the beginning. In the Mississippi Valley, where black willow is abundant, it stands about fifth in rank of woods used. Willow is used as a mixture, and only in the coarse and medium grades. Candy makers have claimed that willow excelsior taints candies, and butter makers have claimed the same about wicker crates, but this is contrary to the beliefs of the Indians and many whites. Willow wood has but limited use in making paper pulp, partly because its short fibers must be mixed with longer-fibered woods. Shredded wood is a small industry and seems to use willows in the limited ways and proportions of the other two industries.

Chemical and medicinal uses. Chief willow uses in the chemical industry are for charcoal, dye-

FIG. 2. Crack willow windbreaks on muck soils (*left* and *right*). Ten years old and 22 feet high after being cut back to 12 feet two years before. (Photo by courtesy of Professor Paul M. Harmer, Michigan State College.)

stuffs, rust preventive, and tanning material. Soft light woods, like willow, were easily charred by primitive methods and, being relatively mineral-free, were suited to chemical uses. Charcoal was the basis of black gunpowder, invented by the Chinese and early brought to Europe. The crack willow (*S. fragilis*) has been a chief source of such charcoal from the beginning, and our colonists brought and planted it here. After smokeless powder was invented, willow charcoal was used in gas masks and in preventing rust in barbed wire and other much-exposed metals. It still makes black gunpowder (Fig. 1).

For home dyeing, willow bark, leaves, and roots have provided dyestuffs from earliest times, and still do. Tannin from willow bark long has served special industries; the famous gloves of Scania, Sweden, have been tanned with it for 3,000 years. It is often stated that our Indian tribes used willow for smoking, like tobacco, but their smoking was ceremonial, not a habit, until after the white man set the example. Many plants, including willow, were used, even under the name *kinnikinnik*, often said to be wholly willow. In the Arctic, the Eskimos collect the fluffy seed hairs in summer for use as tinder in winter. Dried willow leaves have been used to adulterate tea, both here and in the Orient.

Willow bark, charcoal, buds, leaves, twigs, and flowers have been used in medicine by both primitive and civilized man throughout historic time, mostly as decoctions and infusions. These have been used for every kind of ailment, disorder, and disease of every part of the human body, external and internal. Some uses had a basis in fact and some were pure superstition. Salicin, a glucoside from willow bark, has been in the U. S. Pharmacopoeia since 1820. First used as a quinine substitute, it now is employed as antiseptic, antiperiodic, febrifuge, antirheumatic, tonic, preservative, and skin healer. The ancients were not wholly wrong.

Cordage and clothing. Of willows, the bark, inner bark, or bast, and the silky seed hairs have been used for fiber, in both Old and New Worlds. Indians made twine, fishing lines, and fish nets from strips of bast fiber joined at the ends and rolled in pairs over the thigh. Stouter cord for backing fish nets was made from more and heavier strands. The Indians also made mats and sandals from this twine, and women of some Arizona tribes made skirts from strips of bark first buried in blue mud, then washed and dried. The soft fibrous strips were cut to the desired length and fastened thickly to the belt. In northern Europe, the abundant seed hairs have been used, in mixtures of one-third cotton and two-thirds willow hairs, for making clothing.

Food and feed for man and animals. An amazing array of animals, including man, obtain some of or all their food from willows. The list includes many mammals, various birds, numerous kinds of insects (plus termites), and also parasitic fungi and mistletoe.

Willows are a staple food for man under arctic conditions. Scurvy, the dread dietary disease, kills when vegetables are lacking. Circumpolar arctic natives regularly prepare quantities of fresh vegetable matter for winter use, and willow buds, twigs, leaves, and catkins commonly are used; root bark and inner bark (cambium), occasionally. Stems, leaves, and flowers of many herbaceous

plants may be included. The material may be eaten as salad or fermented to sauerkraut, supplies of both being preserved in oil for winter use. Masses of willow twigs and leaves from the paunches of slaughtered deer and caribou are eaten in emergencies by Yukon natives; lichens, willow twigs, and even evergreens may be gnawed by stranded natives and explorers in dire need.

The inner bark of tree willows was dried, powdered, and used for making bread in northern Europe and by American colonists in times of great scarcity, and willow leaves are eaten in China when the crops fail. Willows are listed as honey plants in forty-four states and many countries; early-flowering willows furnish honey for brood-rearing, and surplus for sale.

Willows furnish an immense amount of forage throughout the Northern Hemisphere, mostly as browse for livestock and cud-chewing game animals (antelope, bison, caribou, deer, elk, moose, musk oxen, and reindeer). Practically all kinds of willows are used for forage, because some are found in every environment and because different kinds of mammals, birds, and insects prefer different willows.

Much forage from all forested areas is browse from woody plants, willows being favorites. The U. S. Forest Service derives large annual revenues from grazing fees, and our National Parks and other public areas support abundant game animals. In the Arctic, both livestock and wild cud-chewers browse largely on willows in summer, and the latter do so in winter by pawing away the covering snow. Because the arctic summer is short, the leaves and catkins often do not fall in autumn, and so furnish extra browse in winter. Willows taken from the paunches of slaughtered reindeer have been identified as a guide to good winter grazing areas.

Willows frequently have saved livestock and game during emergency shortages caused by severe drought or cold in dry lands, and they have been introduced into Australia for this purpose. When cattle are marooned on high spots by river floods, they may be fed on willows gathered in boats. In Eurasia, willow shoots are dried or siloed for winter feeding.

Young bears will eat willow buds occasionally. Among rodents, or gnawers, beavers eat willow bark habitually and mountain beavers store willow twigs and branches in their burrows. Muskrats will gnaw willows sometimes. The rabbit family destructively debarks the stems of wild and cultivated willows, and the arctic snowshoe rabbit debarks above the snowline in winter, competing with the moose herds for food. The mountain conies cure little willows in their "haystacks" for winter use. Mice may girdle willow trunks or gnaw the roots until plants blow over, or debark branches to the very tops of trees.

Many birds of widely different families use willows more or less commonly for food: Different kinds of grouse all eat willow buds and twigs to some extent, as does the California quail; the willow ptarmigan uses the arctic willows for both shelter and food throughout the year; ducks scoop up floating buds, leaves, and capsules as they swim, and probably eat some from trees when roosting;

FIG. 3. Holding a new road fill on a California mountainside by thick plantings of red willow (*Salix laevigata*). (U. S. Forest Service photo.)

sapsuckers eat the inner bark and drink the sap; and many other birds occasionally feed on willows.

Numerous kinds of insects live on or in willows and obtain food from them during some of or all their four stages. Bees and wasps use willow pollen extensively in early spring for starting comb, and gather nectar for honey. Some butterflies and moths feed on nectar, but their worms feed on willow tissues. Many infesting insects create curious distorted growths, called galls, in twigs, buds, leaves, and flowers and live and feed inside them; others eat the inner bark, or tunnel in the wood. Termites eat out the wood of posts, poles, boards, and planks, often injuring buildings seriously.

For cover, shade, and homes. Willows furnish temporary cover or shelter to many kinds of insects, birds, and animals, including man. This is used, at times, to avoid winds, storms, or sun, to escape from enemies, or to rest. The dense growth of willows gives a maximum of protection. Even some water birds, such as ducks and herons, roost in willows near the water. An exploring party, threatened by Indians in Colorado, "retired to a small grove of willows" to make their defense.

Natural willow growth furnishes shade for animals coming for water and to rest after feeding. Tree willows with two to four leaning trunks afford maximum shade, and low-hanging branches keep biting insects off. Farmers often plant such trees near watering places and barns. Jack rabbits on the plains will sit in the shade of willow fence posts on hot days, moving with the sun. Kiowa women used leafy willow wreaths as sunshades while working. Willows, fast-growing, are used as nurse plants for new-planted, slow-growing trees.

Many kinds of fungi live on or in willows. In Europe, one species of mistletoe grows on willow. One most peculiar "housing development" is provided by the huge old pollarded willows once grown for making gunpowder. These beheaded trunks, covered with cane stubs, collect leaves and dirt, in which grow many kinds of plants, including trees, whose seeds have dropped or blown in.

Willow timber is little used for houses, because it is not durable when exposed. Rafters and floors of such wood, however, kept dry, have been long-lived. Many Indian tribes have used willow poles for their conical tepees and as roofing poles on their flat-topped lodges, hogans, or jacals; these were then covered with thatch and earth.

For windbreaks and as soil-holders. Living windbreaks or shelter belts stop, slow down, or deflect wind sweep. This is needed on islands, ocean and lake shores, river valleys opening to the sea, and on treeless plains. Only thus can crops and livestock be protected from injury. Many plants are cut off by drifting sand and soil particles. Most shrubby willows form close thickets, and tree willows cut back produce the same effect. In wider shelter belts, several other kinds of shrubs and trees are used with willows, whose rapid growth and usual recovery from injury make them favorites.

FIG. 4. Close-up of red willow cutting used for road fills. Note the many vigorous shoots from the driven stem. (U. S. Forest Service photo.)

FIG. 5. Willow mattress in readiness for rock ballast, Sandy Point Bend, Missouri River. To be used for bank protection. (U. S. Army Engineers photo.)

On our muck soils, dry, blowing peat fragments cut off tender truck crops (Fig. 2). On treeless steppes and plains, Old World and American, shelter belts are used to break the force of the winds.

Throughout the world, two gigantic forces, wind and water, work eternally to move soil and sand and gravel to new locations. Removal of fertile topsoil, gullying of land surfaces, and eating away of stream banks may ruin agriculture where occurring. The deposit of these materials, good and bad, may produce ruinous effects elsewhere. Willow cuttings are widely used to protect stream banks, tie shifting sand and gravel bars, to stabilize gullies, hold lake shores, and reclothe mountain slopes denuded by lumbering and/or fires. Levees, dams, reservoir walls, and road fills (Figs. 3, 4) are protected from washing by willow plantings—60,000 on one California levee. Along the lower Mississippi River, Army Engineers hold crumbling banks by huge mattresses or aprons of interlaced living willow poles (Fig. 5) which, weighted down with earth, soon produce an impervious willow thicket. Injury to crops and painted buildings by blowing sand, and the merciless advance of sand dunes into towns or across farms, are stopped by plantings of willows and other sand-holders.

Willows as indicator plants. From earliest history, man has associated willows with water supplies. But willows grow also on dry plains and in deserts, and under these unfavorable conditions they often indicate seeps, springs, or underground flow. Knowing this has saved the lives of water-short desert travelers and prospectors.

The condition of willow clumps in range lands indicates the severity of grazing. If they are not spreading, are browsed to maximum reach, and portions are dying, overgrazing is severe. Willows also indicate the years elapsed since a forest burned, and the presence of excess alkali.

Willows as weeds. It is only fair to record that sometimes willows hinder and harm, instead of help. They hamper irrigation by invading ditches, slowing water flow, causing silt deposition, and using the water; they do the same in shallow streams. Sometimes they invade pastures or forest plantings, but poisoning or heavy grazing will hold them down. Sometimes they clog drain tiles with root growth. They furnish food and housing to many insects, some injurious to them, to man, or to animals. Finally, their abundant pollen causes hay fever in susceptible persons. But all these are trivial compared with the help they give.

ONE HUNDRED YEARS OF CALIFORNIA PLACER MINING

HERBERT A. SAWIN

Mr. Sawin is sales engineer for the Yuba Manufacturing Company, of San Francisco. His article is based on an address given in the symposium on "Mining Methods" at the Annual Meeting of the American Institute of Mining and Metallurgical Engineers at San Francisco, February 13–17, 1949.

VAST changes might have occurred in world history if some early explorer had learned more about the land he had found. Suppose, for instance, that Sir Francis Drake had known about the Sierra Nevada foothill placers only two or three hundred miles from where he left a brass plate claiming for Queen Elizabeth that immense territory now one of our country's greatest treasure stores. (Drake's brass calling card left in 1579 was found a few years ago near San Francisco Bay and can be seen in the University of California library in Berkeley.) The treasure he sought was lying in stream beds and practically on the surface of many square miles of California countryside, a relatively few miles from where he camped.

The course of our national history and development moved from the east coast westward because early European immigrants found land and, later, mineral wealth in New England, New York, Pennsylvania, and in Southern seaboard colonies. The trek West came much later. The fight for survival produced a hardy race and, fortunately, the adventurers who came to California in the days of '49. In 1848 and 1849 enough Americans to outnumber the foreigners heard the cry of "Gold in California." American Army and Navy detachments were already in California because of the war with Mexico and held the fort, so to speak, against other possible claimants.

Gold was not unknown to Californians prior to 1848. Mexicans used a wooden batea, forerunner of the gold pan. The Philadelphia Mint gold bullion ledger bears an entry under date of January 30, 1838, crediting Hussey and Mackay with three gold deposits "from Calafornia." One item (No. 21) is recorded as "309 ozs.—74 dwt. native grains." This probably came from Southern California. The Indians of California also knew of the existence of placer gold, but apparently thought it of little value.

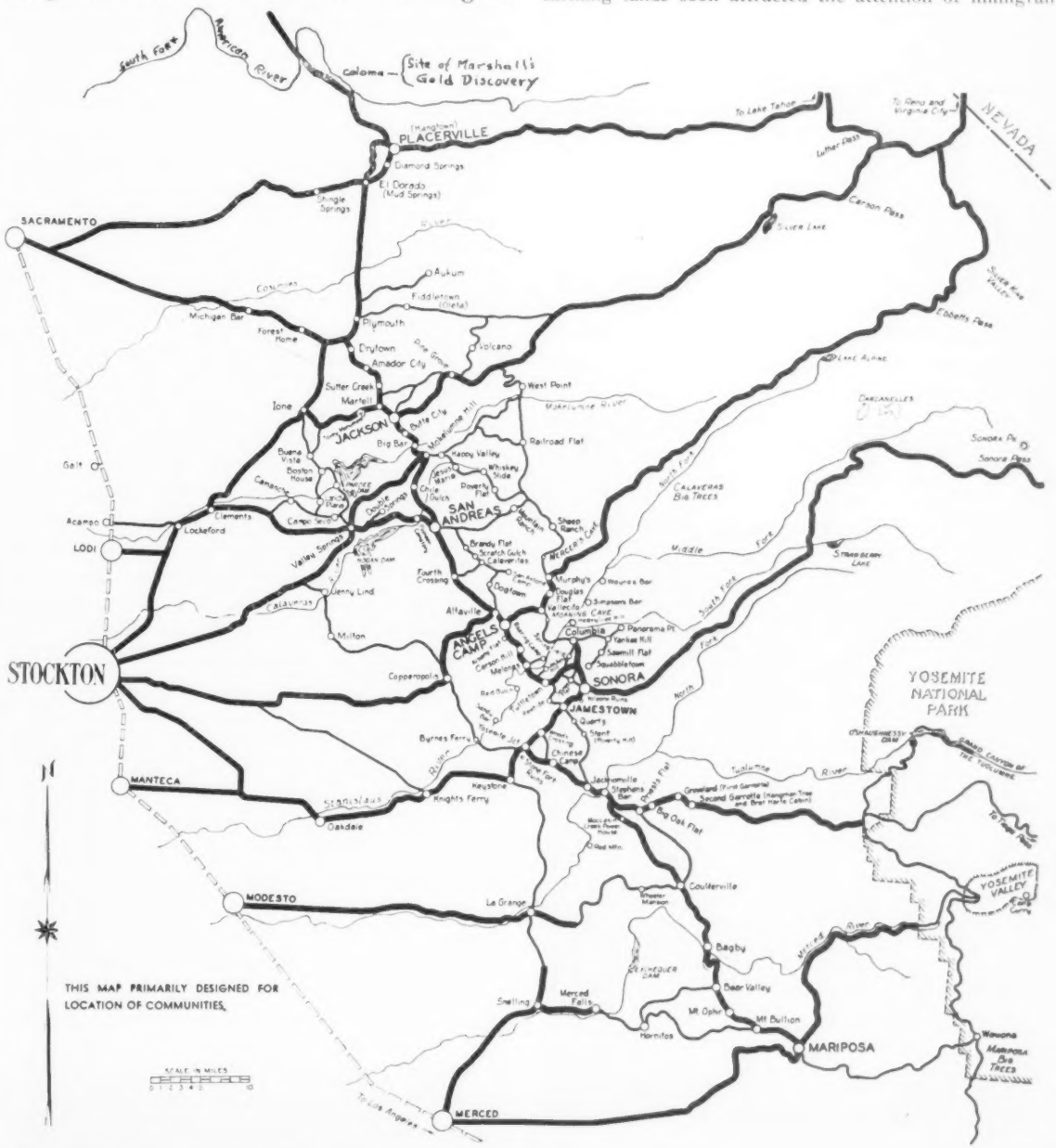
It was James Marshall's discovery of placer gold in John Sutter's millrace in Coloma in January 1848 that brought the hordes of wealth seekers in 1848 and 1849. Hard work and discomfort, disease and short rations—these meant little to the pioneers when gold was to be had for picking it up. Sutter owned many acres of land by legal grant from the Mexican government, but squatters overran his property, and the unfortunate Swiss, who had become a Mexican citizen, spent his last days vainly seeking redress from the Congress in Washington. By 1850 probably 100,000 persons had come to California, and by the end of 1852 the population, not including Indians, was about 223,000. The records are not complete or conclusive, but the 1850 census places the percentage of females in California at 7.5. The new country was a place for men, men who were interested only in the riches to be picked up and taken back home for investment. The thrilling story has been pieced together from many sources by Rodman W. Paul in his book *California Gold* (Harvard University Press). The flush days of placer gold production continued for twelve years or more. The annual value of gold from California, Paul states, reached a peak of over $81,000,000 in 1852. Authorities agree that until as late as 1855 most gold from the state came from placers. Earlier, lode mining had been started in Amador and Mariposa counties. Lode gold in quartz had been found by placer miners, and, after many attempts and failures, methods for mining and milling were developed. That, however, is another story.

Many early surface miners were drifters, always looking for a richer claim, listening to rumors and moving on at the whim of fortune. Our expression "It didn't pan out" can be traced to the experience of men who staked a claim for placer gold and found few or no colors in their pans. The early-day take has been estimated at $20 per day per man as an average, with some, of course, running much higher. In the first few years gold hunters spread quickly over an area extending from the American River drainage basin to the Bear, Yuba, Feather, Trinity, Klamath, Salmon, and Smith rivers to the north. South they mined placers of the Stanislaus, Mokelumne, Cosumnes, Merced, and Fresno rivers. A boom in 1855, built up, some say, by

deliberately false reports, led many miners to the Kern River far south. The boom soon collapsed.

Miners on the move soon found that the deep gravels in the elevated Tertiary channels carried gold. As early as 1850 these were worked by hand, but as knowledge of the formation was gained, new tools were devised, and these brought into being the great hydraulic mining days of the state. Inexperienced miners probably reinvented rockers, sluices, and other equipment because of the urgency and the need for tools. Miners with experience in Georgia or South America were held in great esteem because of their knowledge of gold-mining equipment. It is estimated that by 1876 more than $100,000,000 was invested in hydraulicking equipment, with an annual yield ranging from $11,000,000 to $13,000,000. In California Division of Mines Bulletin No. 92—*Gold Placers of California*—Charles Scott Haley has this to say:

While the hydraulic mines were flourishing, the owners apparently overlooked the growth of another industry which was one day destined to drive them from their own field by the action of the courts. The broad valleys, where the tributaries of the Sacramento and San Joaquin unite with these streams, teemed with fertility and these rich farming lands soon attracted the attention of immigrant



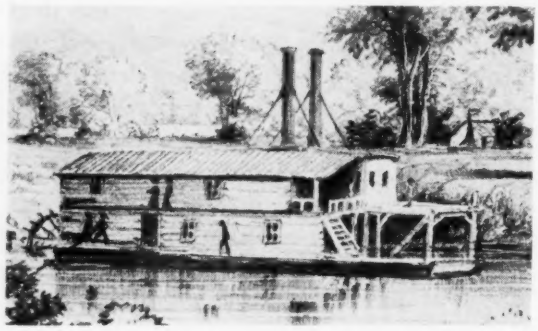
The California gold country. The place names date back to the early days, and many of them are still in use. (Map by courtesy of Stockton, California, Chamber of Commerce.)

farmers. Land, which the miners could originally have bought for a song and held as a perpetual dumping ground, steadily mounted in value and its increasing productivity permitted the farming interests gradually to outgrow the mining in economic importance.

The accumulation of debris in the rivers was long a source of annoyance and considerable damage to the farmers. Even during the days of ground sluicing, the great flood in the winter of 1862 covered the richest bottom and orchard lands along the Bear and Yuba Rivers with tons of debris from the gold washing. At this time however, mining was regarded as the more legitimate and powerful industry, and but little protest was made. As the strength of the agricultural interests grew, protests against the overloading of the rivers became more and more frequent and more powerful until the struggle culminated in the famous Sawyer decision on January 23, 1884. This decision, in the form of an injunction, handed down by the United States Circuit Court, in the case of Edwards Woodruff *vs.* North Bloomfield Gravel Mining Company *et al.*, wiped out at one blow property values exceeding one hundred million dollars and indefinitely postponed the addition to the world's wealth of what has been roughly estimated at from five hundred million dollars upwards in the value of placer gold.

The struggle between miners and farmers resulted in the passage by Congress in 1893 of the Caminetti Act. This created the California Debris Commission, with jurisdiction extending over the drainage area of the Sacramento and San Joaquin rivers. Although the law does not make hydraulic mining illegal, it cannot be carried on if directly or indirectly it results in injury to the navigability of the two rivers, or injury to adjacent lands. Dams

Long Tom used for ground sluicing for gold. California, about 1852.



The "Phoenix," first dredge in California. Used on the Yuba River about 1850. (Photo by courtesy of the California Historical Society.)

have been built on the Yuba, but charges for impounding tailings are high. The intent of the Act, as miners hoped, was to return hydraulicking to its former important status. This has not been accomplished, although some small-scale hydraulic mining is done in Sierra Nevada rivers. Today, to see hydraulic mining in California, one must visit mines in the Trinity and Klamath river areas. These are outside the jurisdiction of the Caminetti law. There are those who claim that instead of harming farmlands, hydraulic slickings built up and increased the fertility of lands along the rivers. It is well known that many low spots, once breeding grounds for malaria-carrying mosquitoes, were filled in and the surface elevated many feet. The health of near-by residents must definitely have been improved by the elimination of such pestholes.

An important contribution to California gold history came through the operation of river mining companies. By the use of dams, ditches, and flumes, streams such as the Feather and the Yuba were turned from their natural courses and the bottom gravel washed for values. Potholes were rich sources of accumulated gold, deposited there by the stream action of thousands of years. Water could be turned aside and controlled only during the low-water season, say, from July 1 until the early rains started in November. The ventures faced two variables, the length of the working season and richness of the bottom gravel. Eastern and foreign capital was invested heavily in river mining, and before 1858 there were many such projects, involving dams and flumes, costing $100,000 or more each. Daily operating expense was high, but when luck held out large profits were realized. Conversely, great effort and cash outlays sometimes brought failure. Early high water sometimes washed out wing dams and destroyed a season's preparatory work before enough gold had been recovered to pay the costs, let alone any profits. Water is the principal tool of placer mining.

but too much of it at the wrong time was bad news to river miners.

Drift mining for gold is peculiarly a California development, brought about by lava flows covering ancient gravel beds. Under table mountains, such as those in Butte and Tuolumne counties, streaks of gold, and often nuggets of good size, are found. This form of mining was an early development, and there are still mines of this type which it pays to operate. Many of the beautiful specimen nuggets to be seen today are from drift mines.

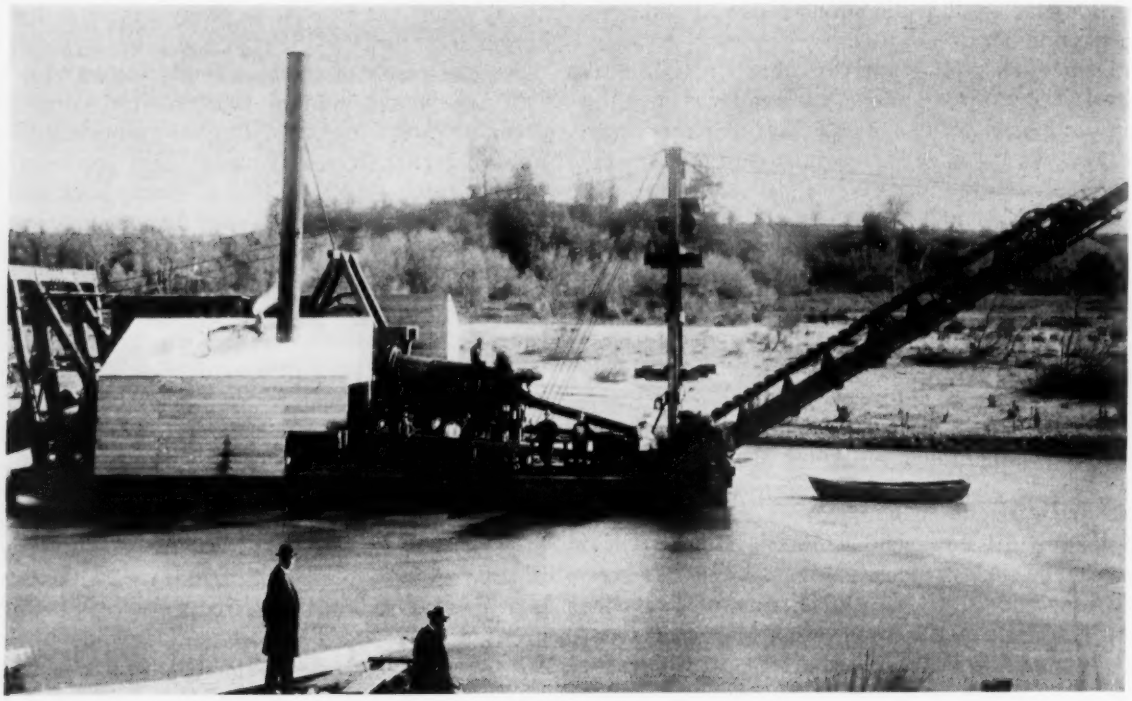
Space does not permit many statistical references, but it would seem desirable to trace briefly the production of gold in California. Most authorities agree that a high point was reached in the years 1853 and 1854, with most of the production in placer gold. Published figures range from about 62.5 to 69.5 millions of dollars annual value. From then until the new century the trend was downward. The value of placer gold reported in *Minerals Yearbook* for 1903 is $4,052,761. At that time dredging was beginning in California, and low-grade deposits, formerly too nearly worthless for even a Chinese miner to work, could be mined profitably. Large volumes of gravel could be dug and water in the dredge pond used over and over. With dredging methods improving, the placer gold industry of California contributed to greater production, and from 1903 to 1908 production about doubled in value. From 1909 to 1920 the annual value was in the 8–9 millions bracket. The average value per cubic yard of gravel for a twenty-year period—1920–40—was about 10 cents. Prior to 1920 the average value may have been much higher—say, 25–35 cents in certain rich areas.

Totals then fell off again until the new price for gold made marginal dredging properties worth mining and brought on a search in the foothills for small placers that the forty-niners, and later the Chinese and others, had overlooked. Placer production climbed again to a high in 1941 of $25,130,455, with dredges credited with over $22,500,000 of that total. High costs, because of war demands for labor, and shortages of material, forced the dredge operators to curtail or to shut down. Finally, in 1942 WPB Order L–208 fell like an axe, and California placer gold miners virtually were through. Since the war, of course, inflation has automatically lowered the purchasing power of gold and, combined with high operating costs, has made full recovery impossible. The year 1948 should show a total production worth about $15,000,000 in inflated currency, not comparable to the $15,000,000- to $20,000,000-years that were common during the 1870–90 period, when the whole family dined out in style at today's price of hamburger for four.

As one result of the new gold price, a certain form of placer mining was revived—dragline dredging. Steam-operated dragline outfits had been tried in earlier days, and one at least was used in Siberia prior to 1912. The advantages of using Diesel-powered draglines soon became apparent. In 1933 Harry England built near Oroville a floating washing plant, similar in operation to a small dredge, without a bucket line. He used a dragline on the bank ahead of the washing plant to excavate and feed gravel to a large hopper on the washing plant. Since then many similar plants have been built, with great improvements. Many small and relatively rich properties were mined in this manner during the succeeding ten years. More than 100 draglines were reported to have been used in California, with a total annual production going over $7,000,000 in 1940 and to nearly $8,000,000 in 1941. Production then tapered off as fast as it had climbed, and at last the industry felt the effect of L-208, plus high costs. Since the war a few such plants have started work again.

Bucket-line dredging in the state has been resumed on a greater scale than any other type of gold mining. Despite high costs, experienced operators have been able to keep going by taking advantage of every opportunity to improve methods. One department of the dredging industry, particularly, has received much attention. Jigs were used as early as 1914 on dredges, but only in recent years have they been given the thought and attention due them as gold savers; most modern California dredges now use jigs. Neill jigs were tried on California dredges in the early years, and at least one dredge today still uses them. Others are using Bendelari, Pan-American, and Yuba jigs.

Typical rocker used by the forty-niners. (Photo by courtesy of V. Covert Martin.)



First successful dredge in California. Built in 1898 by the Risdon Iron Works, it was used near Oroville.

Amalgamators and other mechanical devices are required on jig-equipped dredges, and extra men to operate them.

Lessons learned in California have been useful in dredging fields in other parts of the world. Space will not permit a detailed account of the

Malikoff diggings, Nevada County, California, a large hydraulic operation. (Photo by courtesy of V. Covell Martin.)

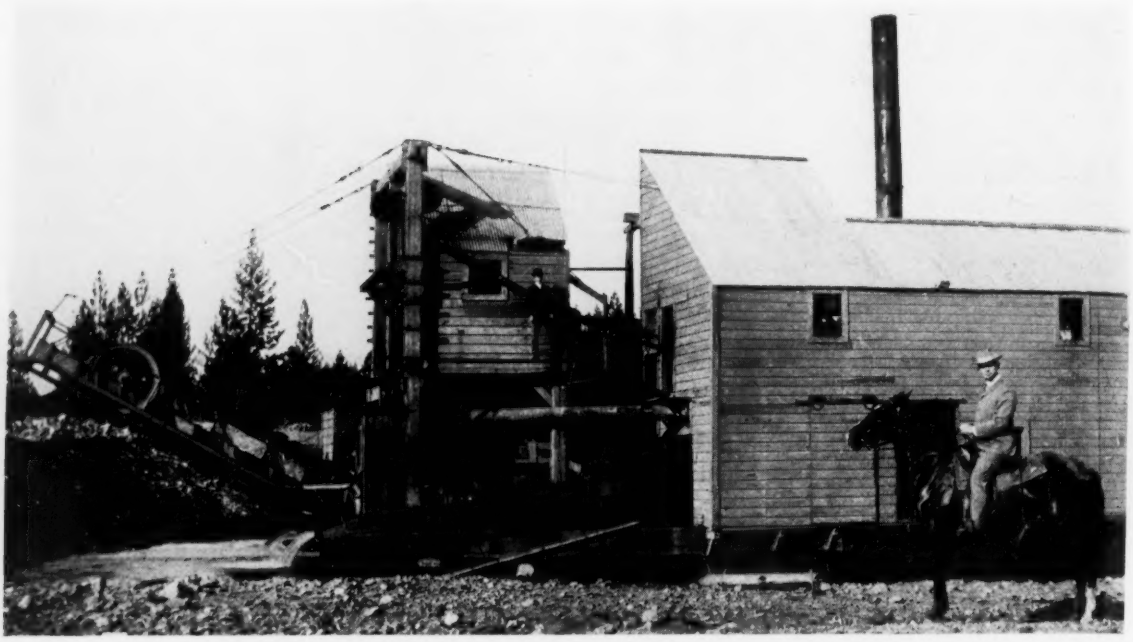
many early operations, but by 1913 bucket sizes had reached 13.5 cubic feet capacity on Yuba River dredges, operated by Yuba Consolidated Gold Fields. Later these were increased in capacity to 15 cubic feet and then to 18 cubic feet each. Digging depths of 60 feet were once thought to be maximum, but now two dredges in California dig 112 feet and 124 feet below water level and against banks 50 feet high if necessary. These dredges have monitors forward and high-pressure pumps to supply water needed for sluicing down high banks or old rock, in the latter case when working through old tailing piles.

Problems of a technical nature have been a common occurrence ever since gold dredging, as we know it in California, Alaska, and other Western areas, was first attempted. The first dredge in California, called the "Phoenix," appeared on the Yuba River in 1850. Newspaper files still available tell of it as a new venture and report it a failure for mechanical reasons. One reporter stated that it was more successful in getting money from shareholders' pockets than in getting gold from the Yuba. The year 1948 marked the golden anniversary of successful dredging in California—fifty years of producing gold worth about $500,000,000 at today's price of $35. Half a billion dollars is small change to some of our economists, but half a billion in gold is a stable, nondestructible commodity.

A striking comparison between California gold placers of 1848 and the same area today can be found in a report entitled *Small-Scale Placer Mines as a Source of Gold, Employment and Livelihood in 1935*. This is a report by the Works Progress Administration covering the attempts made by some 28,000 or more persons to mine gold in many of the same California creeks and rivers where the pioneers worked. The forty-niners found gold from the grass roots down in earth that ran many thousands of dollars per acre. The 1935 miners, as unskilled at first as their predecessors, and obviously more in need than the pioneers, found hardly enough gold to buy beans. Gross yearly earnings are given in the preface of the report as $72 per man. California Division of Mines Bulletin No. 135 states that, although no actual count was made, 100,000 persons would be a conservative estimate of the number of amateur miners in 1933 and an equal number in 1934. Small-scale miners in 1937 sold about $44 worth of gold per man to the United States Mint.

The number of persons working the streams in depression years was comparable with the numbers

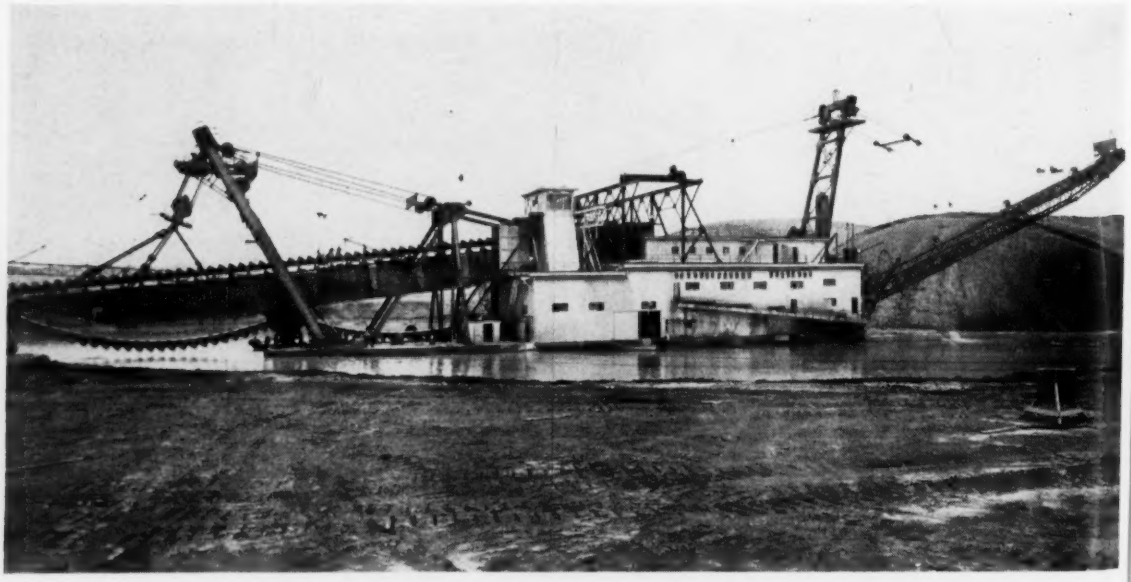
Hydraulic gold mine near Weaverville. Sluices in front show the gold being recovered from the muddy water.



Risdon dredge at Weaverville about 1901.

in 1848 and 1849. Their pitifully small returns, however, tell a story; the vast riches of California gold placers have been added during the years past to the country's store of wealth. It now is gold bullion and counted as an ever-ready gold reserve to back our currency and to inspire confidence in it.

Before building a sawmill at Coloma on the American River, John Sutter and his associates had surveyed prospects for such a mill at Cherokee Flat on the Feather River and at a spot on Butte Creek. A millrace in either place probably would have caught placer gold, since both the Feather River and Butte Creek have had a placer gold history for 100 years, as has the American River where Marshall first found a gold nugget. All are today sources of placer gold, and dredges are working in and near these streams as these words are being written.



Modern dredge used by Yuba Consolidated Gold Fields digs 124 feet below water level, against a bank 50 feet high if necessary, and uses buckets of 18 cubic feet capacity. Digging ladder is shown out of water for inspection.

SCIENCE ON THE MARCH

THE SIXTEENTH INTERNATIONAL GEOGRAPHICAL CONGRESS

THE XVI International Geographical Congress met in Lisbon, Portugal, April 8–15, 1949. In this first such meeting since that at Amsterdam in 1938, geographers from 29 countries presented many professional papers and discussed some of them. The International Geographical Union revised its statutes, admitted 4 new countries, manifested an intention to participate in the solution of world problems, and accepted the invitation to hold the XVII International Geographical Congress in the United States in 1952.

Visitors were delighted with all that they saw of Portugal—a land with Mediterranean climate, not rich in an agricultural sense but intensively cultivated. Being dispersed among many Lisbon hotels, the delegates soon came to know the capital city, to admire its cleanliness and order, and to appreciate the universal sense of beauty revealed in the tiled walls of the houses and the profusion of flowers. Modest taxi rates facilitated movement everywhere.

Representation at the Congress and membership in the I.G.U. There were 330 registered individuals (the majority of whom were professional geographers) in actual attendance, including about 140 Portugese. There were 38 from the United States, including 7 with "official" credentials from the National Research Council. The total number registered was 706, of which 652 were in advance, including 43 subscribing institutions.

The composite list of 43 countries in Table 1 includes all represented in the published list of advance registrants (individuals and institutions) and the 30 countries that are now members of the International Geographical Union (in capital letters). Four of the latter (China, Hungary, India, and Turkey) were admitted at the closing session of the General Assembly.

Sixteen European countries were represented at the Congress. The only country behind the Iron Curtain actually represented was Poland—by a Polish woman geographer resident in Great Britain. From south of the equator the only countries represented were Argentina, Brazil, Peru, and Uruguay—all in South America. From the Americas, in addition to the 4 south of the equator, there were Canada, Colombia, Cuba, the United States, and Venezuela. From Asia, only Ceylon, China, and Turkey were represented; from Africa, only Egypt.

TABLE 1

un.	ARGENTINA	—	Lebanon
—	Australia	—	MOROCCO
un.	Austria	*of.*	NETHERLANDS
of.	BELGIUM	—	NEW ZEALAND
of.	BRAZIL	*of.*	NORWAY
—	BULGARIA	—	Palestine
of.	CANADA	*of.*	Peru
un.	Ceylon	*un.*	POLAND
—	CHILE	*of.*	PORTUGAL
of.	CHINA	—	RUMANIA
un.	Colombia	*of.*	SPAIN
of.	CUBA	*of.*	SWEDEN
—	Czechoslovakia	*of.*	SWITZERLAND
of.	DENMARK	*un.*	TURKEY
of.	EGYPT	—	UNION OF SOUTH AFRICA
un.	Finland	*of.*	UNITED STATES OF AMERICA
of.	FRANCE	*un.*	Uruguay
of.	GREAT BRITAIN	*of.*	Vatican
of.	GREECE	*of.*	Venezuela
—	HUNGARY	—	YUGOSLAVIA
—	INDIA		
—	Iran		
of.	ITALY		

of. = represented by a delegation accredited as "official" (20, including Portugal and the Vatican);
un. = represented by an unofficial delegation (8 countries);
— = not represented at the Congress (14 countries, of which 9 are members of the I.G.U.; 6 countries were represented in the published advance registration, viz., Australia, Czechoslovakia, Iran, Lebanon, Palestine, and the Union of South Africa—the latter being a member of the I.G.U.).

Languages. German, English, Spanish, French, Italian, and Portuguese were recognized for use in the Congress. French and English were spoken almost exclusively, French predominately. Translation services were, on the whole, inadequate. Simultaneous translation, with earphones for the listeners, is clearly the most satisfactory for such meetings. Linguistic competence in both French and English on the part of delegates from many countries was marked, although linguistic laziness of delegates from the United States was unfortunate.

The clarity of the French lectures by Professor Ribeiro, on the excursions which he led during the Congress (to the Arrábida on Sunday, on the Tagus on Tuesday, and in the city of Lisbon on Wednesday), was remarked and appreciated by many.

I. THE CONGRESS

1. *Formal opening, closing, and plenary sessions.* The formal sessions, as usual, were well planned

and impressive. At the opening session, held in the Palace of the National Assembly on April 8, at 3:00 P.M., the President of the Republic of Portugal, General Carmona, presided in a scene of military display with appropriate music, and in the presence of part of the diplomatic corps. Professor Amorim Ferreira, chairman of the organizing committee of the Congress, gave the address of welcome, weaving Portuguese colonial history and geography into the background. Professor Emmanuel de Martonne, of France, president of the International Geographical Union, responded for the guests and recounted the history of keeping the union alive since the meeting in 1938.

Professor Boerman, of the Netherlands, and Professor George B. Cressey, of the United States, vice-presidents of the I.G.U., spoke briefly, the latter correlating the gathering of geographers with world problems and professional obligations.

At the first general assembly of the I.G.U., on the afternoon of April 9, President de Martonne outlined in general terms the problems with which the Executive Committee had been dealing, upon which action might be feasible by the time of the second general assembly on April 15. (The actions taken at the second general assembly of the I.G.U., on April 15, are separately dealt with in Part II of this report, relating to the International Geographical Union.)

The closing session of the Congress was fittingly held at the Lisbon Geographical Society, which was in the setting of a large museum reminiscent of the great days of Portuguese exploration and colonial expansion. Professor de Martonne presided and graciously expressed the thanks of all the delegates for the hospitality and cordiality of Portugal and its people. Professor Orlando, as secretary of the organizing committee, related some of the problems that had been faced and met in planning and arranging for the Congress.

Professor Cressey, as the new president-elect, expressed sincere appreciation of the delight of many in the charm of Lisbon and Portugal and of the arrangements for the Congress and the excursions. He remarked that the I.G.U. "belongs to the geographers of the world" and expressed the hope that applications for membership may be received from countries other than the present 30 members. He noted the expanding interest typified in the fact that the I.G.U. now has a vice-president in South America and another in Asia. He invited suggestions from geographers everywhere, and added that it is hoped to inaugurate a news letter which may be widely distributed to geographers throughout the world.

2. *Section meetings.* Except for the general sessions at the beginning and end of the Congress, already described, all the meetings were those of the following sections:

I. *Cartography.* (President, J. K. Wright; secretary, B. W. Adkinson; both U.S.A.)
II. *Physical Geography.* (Presidents, A. G. Ogilvie, Great Britain, and Niels Nielsen, Denmark; vice-presidents, F. Hernandez-Pacheco, Spain, and P. Birot, France; secretary, David L. Linton, Great Britain.)
III. *Biogeography.* (President, H. Gaussen, France; vice-president, P. Dansereau, Canada; secretary, D. Duarte de Castro, Portugal.)
IV. *Human and Economic Geography.* (Presidents, Dudley Stamp, Great Britain, and Max Sorre, France; vice-presidents, O. Tulippe, Belgium, and Amorim Girão, Portugal.)
V. *Geography of Colonization.* (President, Ch. Robequain, France; secretary, Harrison Church, Great Britain.)
VI. *Historical Geography and the History of Geography.* (Presidents, R. Almagià, Italy, and Joaquim Bensaude, Portugal; vice-president, Damião Peres, Portugal; secretary, Angela Codazzi, Italy.)
VII. *Methodology, Teaching and Bibliography.* (Presidents, Christovam Leite de Castro, Brazil, and Ch. Burky, Switzerland; secretary, Alice Garnett, Great Britain.)

From 3 to 6 questions in the field of each of the 7 projected sections, totaling 30 questions, were circulated in advance in order to stimulate and channelize the preparation of papers to be presented at the Congress. The responses were quite uneven. Sections I, II, and IV were especially well attended; some of the others had few participants.

The sections are not prescribed by the I.G.U. statutes but are planned by those organizing a congress. The experience of the Lisbon Congress in sectional organization will be useful in making plans for the Congress in 1952. Only a few comments on the section meetings can be included in this report.

In Section I, 37 communications were received, 4 not read; 23 were reports on cartographic work or projects in the countries (11) of those who read papers. The section voted to support the following propositions:

1) That a Commission be appointed to review the International Map of the World at 1 : 1,000,000 scale with a view to its use as a base map for all geographical purposes, and to give special attention to the production of an outline edition, or editions, to serve as a base map on which ecological and statistical data of geographic value may be overprinted.

2) That a Commission be appointed to study and encourage the production of a population map of the world at a scale of 1 : 1,000,000.

In Section II, 28 papers were read. There was

vigorous discussion of geomorphological questions by eminent specialists, with "models of clear thinking and presentation." Recommendations as to topics to be discussed at later congresses were formulated.

In Section V (colonization), 15 communications were received: 8 on black Africa, 1 on North Africa, 4 on South America, 2 on colonial territories in general. It was agreed that the subject of colonization is too large and vague for a section, and it was suggested that it be replaced at the next Congress by a section on the human geography of tropical (or desert) countries or areas.

3. *Field excursions.* The field trips or geographical excursions, one preceding the Congress and short ones during the Congress, were exceptionally well planned and managed—routes, timing, lectures, meals, and lodging. Those following the Congress lived up to the same high standards.

The excursions preceding and following the congress were:

A) Minho, Tras-os-Montes, and the Valley of the Douro (7 days). Leaders: A. Jorge Dias and Carlos Teixeira.
B) The central littoral and the calcareous massif of Estremadura (6 days). Leader: Fernandes Martins, of Coimbra.
C) Central Portugal (7 days). Leader: Orlando Ribeiro.
D) Estremadura and Ribatejo (6 days). Leaders: Mlle. Virginia Rau and Georges Zbyszewski.
E) Lower Alentajo and Algarve (7 days). Leader: Mariano Feio.
—) Madeira (April 23–May 8 or 9, following all other excursions). Leader: Orlando Ribeiro.

The 31 who went on Excursion *D*, 16 from the United States (the only excursion preceding the Congress), were enthusiastic about the glimpses they got into the life of the people and their economy—fishing, fruit growing, the wine industry, and ceramic production. Admiration of the charming leadership of Dr. Virginia Rau and of her linguistic versatility was universal.

The two all-day excursions of Sunday, April 10 (during the Congress), should be mentioned: These were the Arrábida; and Sintra, Cascais, and Estoril. Half-day trips during the Congress included a boat trip on the Tagus to its mouth and return, by courtesy of the administrative council of the port of Lisbon; and a visit to outstanding points in the city of Lisbon.

4. *Cartographic exhibits.* Several notable cartographic exhibits were on display in the Superior Technical Institute, in which all the section meetings were held. Canada, France, Italy, Portugal, Switzerland, Turkey, the U.S.A., Venezuela, and the Vatican were represented. That of the United States was the largest and was well organized; having been originally shown in South America, the explanatory notes were in both Spanish and English. Deterred by an anticipated exhibit fee that did not materialize, the British exhibit was not shipped to Lisbon.

II. THE INTERNATIONAL GEOGRAPHICAL UNION

The revision of the statutes, the establishment of a new scale of contributions by member countries, the discontinuance of certain commissions and the creation of others, the decision to hold the next Congress in the United States in 1952, and the election of new officers of the Union, were among the most significant acts taken at the Lisbon meeting.

1. *Revision of the Statutes of the I.G.U.* At the closing general assembly, April 15, the statutes were revised, in general accord with recommendations of the Executive Committee. The principal changes made (the head of each official delegation casting one vote, in most instances) are summarized below:

1) The number of vice-presidents was increased from 6 to 7, elected by the General Assembly; one of them is named by the Executive Committee as first vice-president, available to replace the president if necessary.

2) The Executive Committee is to cooperate in the organization of international congresses.

3) Each Commission will be composed of a maximum of 6 members and a limited number of corresponding members (partly in order to enable regular commission members to meet, within budgetary limitations).

4) On scientific matters, each individual member registered and present at a congress will have the right to vote. On administrative questions the vote will be by countries, each country having one vote.

5) The basis of annual dues was changed. Countries adhering to the Union will be divided into eight categories. Each adhering country pays annually a number of units of subscription corresponding to its category, as follows:

Category	I	II	III	IV	V	VI	VII	VIII
No. contribution units	1	2	3	5	7	9	12	15

Each adhering country will specify the category it desires, which the Executive Committee may reject if judged manifestly inadequate. The value of the unit is to be fixed by each Congress subject to emergency alteration by the Executive Committee.

2. *Other actions of the closing General Assembly.*

1) The *unit of contributions* for the period 1950–52 was fixed at $100 U.S. currency. The

contribution of the United States will therefore be $1,500 per annum for the next three years.

2) The following *Commissions* and their chairmen were agreed upon:

1. Study of Population. C. B. Fawcett (Great Britain).
2. Industrial Ports. W. E. Boerman (Netherlands).
3. Bibliography of Ancient Maps. Roberto Almagià (Italy).
4. Geographic Utilization of Aerial Photography. M. Barrere (France).
5. International Map of the World, 1/M. J. K. Wright (U.S.A.).
6. Agrarian Geography. Daniel Faucher (France).
7. Medical Geography. Jacques May (U.S.A.).
8. Inventory of Land Use. Samuel Van Valkenburg (U.S.A.).
9. Regional Planning. Jean Gottmann (France).
10. Periglacial Morphology. Hans Ahlman (Sweden).
11. Soil Erosion. Edward Ackerman (U.S.A.).
12. Pliocene and Pleistocene Terraces. H. Baulig (France).
13. Tertiary Peneplains. E. de Martonne (France).

3) *Seat of the XVII International Geographical Congress, 1952.* The invitation to hold the next succeeding Congress in Vienna posed a delicate question. The chairman announced that, as Austria is not yet a member of the I.G.U., the invitation was out of order.

Brazil invited the next Congress to meet there; but after due consideration and receipt of further instructions the Brazilian delegation withdrew the invitation for 1952 and cordially supported the invitation of the United States, intimating that they may renew the invitation to hold the Congress next succeeding in Brazil.

Dr. Cressey presented the invitation of the United States in the name of the National Research Council, supported by letters from five geographical associations and societies. He added that the United States has not had the opportunity to serve as host to an international geographical congress since 1904, that 1952 will mark the centenary of the founding of the American Geographical Society of New York, and nearly a half century of the Association of American Geographers. His remark that we shall do our best to assist those who have dollar problems was greeted with applause. The invitation of the United States was accepted, and it is expected that the congress will be held in the early part of the summer of 1952, beginning in New York.

4) *Applications* of China, India, Hungary, and Turkey for membership in the I.G.U. were all acted upon affirmatively. Representatives of China and Turkey were present and spoke.

5) *Officers of the I.G.U.* Professor de Martonne, retiring president, was elected honorary president for life—instead of becoming one of the vice-presidents—in gracious recognition of his service as president since 1938. Mlle. Lefèvre, who has been serving as secretary since 1938, was elected vice-president and was named by the Executive Committee as first vice-president.

The following members of the Executive Committee were elected, to hold office until the end of the XVII congress:

President	Prof. George B. Cressey (U.S.A.)
1st Vice-President	Prof. M. A. Lefèvre (Belgium)
Vice-Presidents	Prof. R. Almagià (Italy)
	Prof. Hans Boesch (Switzerland)
	Prof. G. H. Kuriyan (India)
	Dr. Christovam Leite de Castro (Brazil)
	Prof. Orlando Ribeiro (Portugal)
	Prof. L. Dudley Stamp (Great Britain)
General Secretary	Prof. George H. T. Kimble (Canada)

3. *Service to the United Nations and specialized agencies.* The following resolution was drafted during the Congress, and approved by the old and new Executive Committees in the desire to bring the I.G.U. into effective contact with the United Nations and the specialized agencies.

Whereas the United Nations and all of the specialized agencies are confronted by problems of unprecedented complexity in which the differences from region to region are of great significance and subject to change; and

Whereas geographers make intensive studies of regional distributions of physical, biological, and social phenomena and are constantly concerned with both the persistent and the changing patterns of these phenomena and are endeavoring to improve their techniques of analysis, interpretation, and cartographic presentation—all of which may be of very great value to the United Nations and the specialized agencies;

Now, therefore, be it resolved that the International Geographical Union tender its services to, and record its intention to cooperate with, the United Nations and the specialized agencies, in particular by its practice of creating commissions to investigate and report on such problems as are indicated above.

The general secretary was instructed to communicate the resolution to the Secretary General of the United Nations and to appropriate officers of all the specialized agencies (UNESCO, ICAO, FAO, WHO, etc.).

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BOOK REVIEWS

THE MECHANISM OF ESCAPE

Flight from Reality. Norman Taylor. 237 pp. Illus. $3.50. Duell, Sloan & Pearce. New York.

An Outline of Psychoanalysis. Sigmund Freud. 127 pp. $2.00. Norton. New York.

TAYLOR'S *Flight from Reality* recounts what man has done to escape reality, and Freud's *An Outline of Psychoanalysis* (now available in an English translation) attempts to explain why he needs to escape. Taylor deals with what man does, Freud with why he does it, and both have a way of making their stories dramatic.

In the case of Taylor's material this does no harm, presents no distortions, leads to no unwarranted assumptions of overextended generalizations; in the case of Freud the story is based more on theory than on fact, and the inferences, according to the yardstick of scientific method, need further documentation. In Taylor, capital and dividend are in proper relation to each other; in Freud, dividends declared are in excess of available capital.

Taylor's book explores the properties of juices, flowers, seeds, fruits, barks, leaves, and roots in which men, from Cro-Magnon to John Doe, have sought momentary respite from the impact of reality—the reality of self, of other people, or of the inanimate world. As Taylor points out, this quest has "dominated more people than any religion, costs more than any food, and it yields in this country more than two billion dollars' yearly revenue to the United States Treasury." These substances are used by all strata of society, or cultures, from the civilized Man of Distinction—who obtains it from laboratory or distillery or tobacco warehouse—to the Malayan betel-chewer—who obtains his product from nature in the raw. From the exotic narcotics (some of which have their own gods), such as the ololiuqui and peyotl of Mexico, the pituri plant of Australia, the mandrake of Eurasia, on through Indian hemp, marijuana, heroin, morphine, to alcohol, tobacco, and coffee, the story reflects man's need for, and struggle with, these instruments of flight. The use and abuse of such products, as told by Taylor, makes fascinating reading.

And now the question of "Why?" To this difficult question many varied answers have been given—answers which lie, of course, in the realm of inference and involve a jump from what is observed to what is believed to be "behind" the observed. One such answer is that put forward by Freud in his system *An Outline of Psychoanalysis.* This system probes the Why? of human behavior from a broader point of view than the mere attempt of man to escape reality, but the Freudian emphasis on the Pleasure Principle and the Reality Principle are directly related to this question.

This last book of Freud's, written in London in 1938 and now translated by James Strachey, is quite literally an outline of the fundamental tenets of psychoanalysis. "It is the aim of this brief work," states Freud, "to bring together the doctrines of psychoanalysis and to state them, as it were, dogmatically—in the most concise form and in the most positive terms."

The question has been raised before, but it is worth raising again in the present context: Is it possible that the Freudian system as a system may one day be cited as another example of man's myth-making behavior through which he attempts a flight from reality? Only time, and more psychological evidence about man, can provide the answer.

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BROOD PARASITISM

The Parasitic Cuckoos of Africa. Herbert Friedmann. xii + 204 pp. Illus. $4.50. Washington Academy of Sciences. Washington, D. C.

BROOD parasitism, a species laying in another's nest and leaving the young to the care of the host, has evolved in a number of groups of birds. Much of the study on this has been done on the common cuckoo, *Cuculus canorus,* of Europe, but Dr. Friedmann has also given us a classical study on the parasitic cowbirds of the Americas. In 1924–25 he traveled in Africa to study the parasitic cuckoos, weaver birds, and honey guides there. Since then, from the literature and through correspondence, he has added to his data and analyzed and evaluated them in the light of his long-time interest in the subject. The time is not yet for a comparative monograph on the cuckoos; the Oriental and Australian species are little known. The African data, too, is incomplete, as Dr. Friedmann says, but the wonder is he was able to get so much. This fact-packed, and thought-provoking contribution will enlarge our concepts of the ramifications of brood parasitism.

In Africa certain species of cuckoos tend to select certain hosts—crows, shrikes, babblers, weaver birds, or sunbirds; apparently this reduces competition between species. Individuals of certain species may be host-specific, as when the territory of one cuckoo is a single tree in which is a nesting colony of weaver birds. In such a case the male seems most faithful to the territory and thus may influence the host-speci-

ficity. Resemblance of the parasitic egg to that of the host has, Friedmann thinks, had too much read into it as "perfection." Even if "perfected," is it for the good of the species? The cowbirds, more generalized in behavior, seem more successful. Some of the African cuckoos, laying several eggs a season, are more prolific than their hosts. Males of some species feed fledgling young. This is interpreted as an error in sex identfication, being in reality mistaken courtship feeding of a passive bird by a dominant one.

Geographical variation in color phases, and in nonmorphological characters such as migration, breeding season, habitat, host species selected, and voice are recorded as probably the early stages of further evolution. One species, *Cuculus clamosus*, is said to have two ecological subspecies (p. 83). This would be unique in birds, and can be interpreted as two species.

Puzzling taxonomic points are discussed, and descriptions of the fifteen species and their races given.

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YOUNG MAN WITH A DREAM

The Story of Television: The Life of Philo T. Farnsworth. George Everson. 266 pp. Illus. $3.75. Norton. New York.

GEORGE EVERSON may not know it, but this fine biography he has written on Philo T. Farnsworth qualifies him, I believe, as not only Farnsworth's Boswell but television's as well.

I think the chief virtue of the book is its tremendous worth to the layman, and by that I mean not only those who buy television receivers and bring the magic of video into their own homes, but the cameramen, technicians, actors, stagehands, and program managers all over the country. A review of this great young man's achievements cannot help but give them a new sense of the colossal effort that went into creating their jobs in this new medium of communication.

The book should be prescribed reading for the new owner of a television set, because many of our neophyte viewers are prone to be hypercritical of the programs being telecast in these early years of commercial television. They would thus be reminded of the years of painstaking trial and error that made possible this modern miracle. They would do well, also, to dwell upon the splendidly told story of how Farnsworth had to struggle against almost insurmountable odds to gain the financial backing he needed to develop his inventions. I think Everson did well to avoid romancing this phase of the story. As he tells it, the shrewd bankers who aided Farnsworth were influenced by the possibility of profits far more than the altruistic urge to foster the efforts of a young inventor. This is stark realism and, it seems to me, a valuable object lesson to any young man with an idea.

Since Farnsworth and Zworykin are undoubtedly the fathers of modern television, this fascinating biography—into which the story of television has been so well integrated—is MUST reading. Indeed, I have recommended it as such at ABC.

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MODERN PHYSICS FOR THE LAYMAN

The Universe and Dr. Einstein. Lincoln Barnett. 127 pp. Illus. $2.50. Sloane Associates. New York.

MY FIRST impression of this book was unfavorable. Its title seemed flippant. There is no table of contents, and the numerous short chapters have no titles; hence, to review it, I might have to read it through. But as I read along my dislike vanished.

The book is not flippant or facetious. It is characterized by a sustained effort to instruct the reader rather than to entertain him by outlandish paradoxes or dramatic assertions. Addressed to the thoughtful layman, it is a straightforward attempt to explain the meaning and the value of several of the great generalizations of modern physics. In this difficult task the author has had the help and advice of several top-flight American scientists. Emphasis throughout is on essentials, but good continuity and an admirable literary style make the book pleasant to read.

Modern theories of atomic structure and the dualism of light are discussed briefly. "The basic units of matter gradually shed their substance. The old-fashioned spherical electron was reduced to an undulating charge of electrical energy, the atom to a system of superimposed waves." Thus waves and particles coalesce in "a universe of wavicles."

The various kinds of relativity are treated at somewhat greater length. *Newtonian* relativity, according to which many laws of physics can be stated without assuming an absolute frame of reference, seemed adequate until the famous Michelson-Morley experiment to test the orbital motion of the earth showed where the merry-go-round broke down. Emergency repairs by Lorentz and Einstein are part of the *special* theory of relativity, which now includes the revolutionary concept of the interchangeability of mass and energy. The *general* theory of relativity substitutes a geometrical hypothesis of gravitation for action at a distance.

Dr. Einstein in a foreword says, "The main ideas of the theory of relativity are extremely well presented. Moreover the present state of our knowledge in physics is aptly characterized."

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HISTORY IS BUT BIOGRAPHY

Discoverers for Medicine. William H. Woglom. 229 pp. Illus. $3.75. Yale Univ. Press. New Haven.

UNDERSTANDING of the present is in part predicated upon comprehension of the past. The historical foundations of modern medical knowledge will be belittled only by those whose conceit demands that they be classed as truly original. Concepts evolve slowly and painfully, with many false steps and fruitless digressions into blind alleys. Much of what we "know" today will be discarded as useless, false wishful thinking tomorrow. Historical perspective makes us humble and proud simultaneously; it teaches us respect for the patient efforts of man and for that profoundly significant, though typically simian, characteristic of all discoverers: curiosity.

History may be approached and recorded as a series of events, as a development of ideas and concepts, or as a story of men. In *Discoverers for Medicine,* Dr. Woglom has combined two of these approaches in a series of fourteen delightful biographic sketches describing both the personalities involved and the genesis of concepts. Included are Stephen Hales, the first man to measure directly the arterial pressure; William Withering, great enough to listen to old wive's tales concerning the value of foxglove (digitalis) in cardiac dropsy; Eli Metchnikoff, whose studies of phagocytosis revolutionized our ideas of immunity and defense mechanisms; Benjamin Franklin exercising his burning curiosity upon the question of eyeglasses; Wilhelm Roentgen, discoverer of X-rays. Many of these discoverers for medicine were not physicians, but gifted and sincere amateurs. Hales was a clergyman, Mendel a monk. These personalities come alive once more through the facile pen and deep humanism of the author. The book is highly recommended for leisure reading and a quick bird's-eye view of some of the road over which medical science has traveled so laboriously.

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THE NAZI MEDICAL CRIMES

Doctors of Infamy. A. Mitscherlich and F. Mielke. xxxix + 172 pp. $3.00. Schuman. New York.

THIS thin volume recounts factually a small segment of the monstrous crime against humanity called Nazism. It was written by Germans for German consumption. The depths of depravity to which the proud profession of medicine sank under conditions nurtured in Germany, a country that prided itself on the development of civilization, are still unbelievable—not that there is the slightest doubt concerning the facts but because logic is inadequate to account for the motivations. The thoughtful general comments of Drs. Ivy and Alexander, appended to the translation, indicate their concern and, upon analysis, their inability to penetrate this crucial question of motivation. Dr. Ivy's explanation that "a true scientist must be a moral and an honest man" is an appealing one. Unfortunately, more precise definitions of truth, morality, and honesty at present do not seem to coincide among all peoples or their leaders.

Four years have elapsed since the horror of the Nazi concentration camps was laid bare. Thorough Germanic documentation has established their direct connection with governmental policy and their acceptance by the population. It is tragic that there is no indication that these horrors will not recur. The revision of the Hippocratic Oath by the World Medical Association to include utmost respect for human life, and the resolution of the United Nations condemning genocide are steps in the right direction.

The book is recommended as a footnote to the fuller records of the Nuremberg trials, and to the documentary film on Buchenwald.

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BRIEFLY REVIEWED

Fontes Historiae Botanicae Rossicae. Vladimir C. Asmous. 32 pp. Illus. $1.25. Chronica Botanica. Waltham, Mass. Strechert-Hafner. New York.

ALL botanists will be grateful to have at hand a list of publications which deal in some way with the history of botany in Russia. There are both subject and author indices; the latter gives the name of the author, date of publication, the original title, and a brief summary of the subject matter the article presents. There some full-page half tones showing the plans of several botanical gardens, and a few line drawings, largely decorative in nature. At least investigators are given an opportunity, through this rather comprehensive source book, to know of the existence of, the type of, and the content of many Russian contributions to botanical literature whether or not they are able to follow up and read the complete articles in their original form.

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AUG 1 1949

CORRESPONDENCE

PSEUDO-SONNETS FOR SENESCENT SCIENTISTS

I

Why must the poet always tune his lyre
To sing of lovers' griefs, of passion's glow;
Why must his song be laden with desire
Or in a minor mode be filled with woe?
Must mossy banks and softly rippling streams
Or daring deeds or melancholy death
Run full the gamut of the poets' themes
And claim the voicings of the poets' breath?
Soft moonlight filtering through the whispering leaves,
Fair swaying daffodils on river's brim,
The vines that clamber over thatched eaves,
Ice crystals sparkling on the birch tree's limbs;
The smoke that, through the frosty twilight air,
Suggests the comforts of the toiler's cot—
All these the humble poet sings with care.
These are the counters of the poet's thought.

II

This luring world of transient loveliness
Awakes the poet's soul to lyric song,
But Nature in her sphinxlike quietness
Serenely weaves enchantment yet more strong
And stirs the strivings of the questioning mind.
For he who seeks the wherefore and the why,
Not satisfied with Beauty, looks behind
Its surface where still deeper meanings lie.
On him fair Nature smiles or frowns in vain,
For, manlike, quite regardless of her mood,
He knows, alike in either joy or pain,
She's always eager to be understood.
So, not beguiled by her soft blandishments,
He would disclose what Nature would conceal.
With eager questions of experiment
He seeks her cherished secrets to reveal.

III

With oh what cunning skill and patient care
He fashions scientific traps designed
To catch elusive Nature unaware
And make her captive to his ruthless mind.
With meters, balances, and microscope
He tries to pierce the center of her thought.
"By measurement to know"—this is his hope
That Truth in nets of numbers may be caught.
In terms of matter, motion, time, and space,
Electrons, atoms, molecules, and force,
He bravely seeks her tortuous ways to trace,
And mathematically to plot her course
He catalogues her uniformities
And proudly nominates them "Nature's Laws,"
Neglecting her vexatious vagaries;
He'll not allow effect without a cause.

IV

Persistently he questions, till, forsooth,
Discouraged with the never-ending quest,
He wonders: "Does she always speak the truth?
Let Nature *take* her course, I'll take a rest."
Surprised, that for the time she's not pursued,
Dame Nature drops her mask of seeming guile,
Turns to her weary son in melting mood,
Bestows the favor of her rarest smile.
"You must not take me for a simpleton
And, fretful, charge that you have been misled.
I answer truly but, my foolish one,
My answers still must be interpreted.
I'm but the outer aspect of your mind.
Consider well. Though I admit 'tis true
I give half answers, yet you still must find
The other half, my dauntless son, in you."

Renewed, still eager, but a whit less bold
Humbly he feels new truths within him stir.
His colleagues smile. "He's growing old.
Our scientist has turned philosopher."

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WORLD RESOURCES

Mr. Wilhelmy's reference to the views of the soil conservationists as "less well-founded opinions" ("Correspondence," May 1949) is unfortunate. The critics of Vogt and Osborn generally overlook the fact that the much-discussed books of these authors are very well documented. Mr. Bennett, in his article on "Population and Food Supply" (January 1949), seems also to have overlooked a number of other facts.

Soil erosion, soil fertility, and efficient land utilization are primarily problems of the physical and natural sciences. With few exceptions, economists are neither well trained in these fields nor well acquainted with recent studies of the physical and biological basis of land utilization. Their judgments of the broader aspects of population and food potentials, etc., are therefore limited by economic horizons. Mr. Bennett's paper is an illustration of this fact; its economic implications are illuminating, but geographers and geologists will find some of its statements naïve.

One may well question the assumption that Vogt's wide field experience and his numerous specific examples lead to "less well-founded opinions" on soil erosion than a library study of food habits. Short-run economic conditions are not necessarily a reflection of major physical trends, and it is dangerous to use purely economic data as a basis for conclusions that depend on physical facts. Mr. Wilhelmy will find ample confirmation of Vogt's and Osborn's general thesis in the reports of scientific surveys made in all parts of the world. The leading geographical journals will tell him the same story. But a few weeks in the field in, say, our own arid Southwest, might prove more enlightening than a barrel of economic statistics.

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